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Summary of 2010 Herring Acoustic Surveys in NAFO Divisions 4VWX

Résumé des relevés acoustiques sur le hareng effectués en 2010 dans les divisions 4VWX de l'OPANO

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ABSTRACT

Automated acoustic recording systems deployed on commercial fishing vessels have been used since 1997 to document the distribution and relative abundance of Atlantic herring from industry vessel surveys and fishing excursions in the Bay of Fundy and coastal Nova Scotia area within Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX. In 2010, regularly scheduled surveys at approximately 14 day intervals were again conducted on the main spawning components, and the spawning stock biomass for each component estimated by summing these results. Six structured surveys were conducted in Scots Bay, two on Trinity Ledge, three on Spectacle Buoy and eight on German Bank. In most cases, these surveys provided good coverage of the spawning areas consistent with established protocols. Additional data from fishing nights were also examined but were not applied to the overall spawning stock biomass.

In 2010, biomass estimates decreased by almost 40% for survey areas in Scots Bay, Trinity Ledge and German Bank to 312,100t. The 2010 estimate for the overall area combined was below the long term average by about 30% and is cause for concern about the health of the remaining spawning grounds in the 4X stock area.

Biomass estimates from surveys of the coastal Nova Scotia spawning components for the Little Hope/Port Mouton, Halifax/Eastern Shore and Glace Bay areas were also examined. Five surveys were completed for Little Hope, four surveys for Halifax and one for the Glace Bay area. There were substantial decreases in spawning stock biomass recorded for Little Hope and Halifax areas, while Glace Bay again showed virtually no fish in the surveys completed.

The first survey since 2001 was conducted during the spring fishery in June 2010 on the Offshore Banks near 'The Patch' and documented 3,579t.

RÉSUMÉ

Des systèmes d'enregistrement acoustiques automatiques installés sur des bateaux de pêche commerciaux sont employés depuis 1997 pour documenter la répartition et l'abondance relative du hareng dans le cadre de relevés de l'industrie et de sorties de pêche effectués dans la baie de Fundy et la région côtière de la Nouvelle-Écosse à l'intérieur des divisions 4VWX de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO). En 2010, on a effectué, à environ 14 jours d'intervalle, des relevés des principales composantes de reproducteurs; on a ensuite évalué la biomasse du stock reproducteur de chaque composante en additionnant les résultats obtenus. Six relevés structurés ont été réalisés dans la baie Scots, deux dans le récif de la Trinité, trois dans la zone de la bouée Spectacle et huit sur le banc German. Dans la plupart des cas, ces relevés ont assuré une couverture satisfaisante des frayères, globalement cohérente par rapport aux protocoles établis. Des données supplémentaires recueillies au cours de nuits de pêche ont également été examinées, sans être appliquées à la biomasse globale du stock reproducteur.

En 2010, les estimations de la biomasse pour les zones de relevé de la baie Scots, du récif de la Trinité et du banc German ont régressé d'environ 40 % pour se fixer à 312 100 tonnes. L'estimation de 2010 pour toute la région combinée était au-dessous de la moyenne à long terme d'environ 30 % et constitue une source de préoccupation pour la santé des autres frayères dans la zone de stock de la division 4X.

Les estimations de la biomasse à partir des relevés des composantes de reproducteurs des côtes de la Nouvelle-Écosse pour les secteurs de Little Hope/Port Mouton, d'Halifax/côte Est et de Glace Bay ont également été examinées. Cinq relevés ont été réalisés pour Little Hope, quatre pour Halifax et un pour le secteur de Glace Bay. On a observé des baisses importantes dans la biomasse du stock reproducteur dans les secteurs de Little Hope et d'Halifax, alors qu'il n'y avait, encore une fois, pratiquement aucun poisson dans les relevés réalisés à Glace Bay.

Premier relevé réalisé depuis 2001, il a été effectué au cours de la pêche du printemps en juin 2010 sur les bancs du large près de l'endroit appelé « The Patch » et il affichait 3 579 tonnes.

INTRODUCTION

Since 1997, the spawning stock biomass (SSB) of Northwest Atlantic Fisheries Organization (NAFO) divisions 4WX herring has been estimated using acoustic surveys conducted by the fishing industry (Stephenson et al. 1998; Power and Melvin 2010). Each year, commercial fishing vessels equipped with calibrated acoustic logging systems undertake both scheduled and unscheduled surveys of herring aggregations on the spawning grounds. The data collected during these surveys serve two purposes. First, when necessary, the data can be analyzed in near real-time, and used as input for the "survey, assess, then fish" protocol to apportion fishing effort on individual spawning grounds. Secondly, the estimates for individual spawning areas have been summed, under specific assumptions about elapsed time between surveys, to provide an annual index of SSB for assessment process. The development and implementation of the automatic acoustic systems represents a major improvement in quantifying fish biomass. Pre-1997 estimates relied on the experience of the observer to estimate the amount of fish from mapping surveys, and are considered qualitative only (Melvin et al. 2002).

The use of commercial fishing vessels to survey and to estimate SSB was initially developed to provide additional protection of individual spawning components within a global total allowable catch (TAC) during a period (1994/95) of declining biomass. The original qualitative approach, commonly referred to as the "survey, assess, then fish" protocol, continues today, but now uses a quantitative acoustic methodology with a standard survey design (DFO 1997; Melvin and Power 1999; Melvin et al. 2004; Power and Melvin 2010) to provide an index of spawning biomass.

Several major improvements to the approach have been made in survey design and in the standardization of survey coverage to a point where they can be considered comparable from year to year (Melvin and Power 1999; Melvin et al. 2003, 2004; Power and Melvin 2010). The purpose of this document is to report and to summarize the NAFO divisions 4VWX stock assessment related survey data collected during the 2010 fishing and survey season.

METHODS

Acoustic and mapping surveys using commercial fishing vessels have been employed to estimate the SSB of individual components within the stock complex since 1999. The methods and procedures are well established and are described in more detail in previous research documents (Melvin et al. 2004; Power and Melvin 2010; Power et al. 2011).

Data from the 2010 fishing season were obtained during both standard fishing operations and regularly scheduled structured surveys. Structured surveys were either mapping and/or acoustic surveys (Melvin et al. 2001). In 2010, no major changes were made to the established protocol for either acoustic or mapping surveys.

The 22 surveys scheduled for 2010 were completed on or near the dates planned, and an additional four complete surveys were examined (Table 1). The additional surveys were completed in order to either increase coverage or to ensure that newly observed groups of fish were recorded, bringing the total number of structured surveys to 31. The total number of survey boat nights completed was 235, with 137 from vessels with acoustic recording systems and 98 from 'mapping' vessels without recording systems (Table 2).

In general, structured surveys were conducted in accordance with the protocol established in Melvin and Power (1999), and there was usually good coverage of the defined spawning survey area. A few exceptions to the normal protocols of survey design did take place and these are explained in more detail where they occur below.

DATA QUALITY ISSUES

In the previous years, the main areas of concern with the data included surveying protocols, provision and verification of the raw data and editing, and issues of noise and interference. Most of these issues have been resolved, but some, like not following survey protocols (i.e. doing a series of loops instead of parallel lines) when documenting fish aggregations on non-survey nights, continue to be a problem.

There is a well-defined survey protocol for structured surveys and fishing night school documentation, but it was not always followed and remains an issue. In cases of fishing night surveys by purse seine vessels, there was very poor adherence to survey design with vessel captains rarely establishing a series of parallel transects to document the fish. Rather, the data provided was usually one of an unorganized search pattern common in fishing operations and was very difficult or impossible to analyze. It is important to follow the protocol (a series of stepped parallel lines) for surveying an aggregation or school of fish. Data collections inconsistent with established protocols were again given a low priority for analysis or were not incorporated into the SSB estimate.

A major portion of the processing time is required to download, backup and edit the raw acoustic survey data files. In past years, Department of Fisheries and Oceans (DFO) staff completed this task and received all 'original' raw data files (unedited). More recently, these tasks have been split between the Herring Science Council (HSC) and DFO with the complete raw data received only at the end of the season. In the 2007 review, it was recommended that all raw data files be made available on a regular basis for review prior to finalizing the acoustic biomass estimates (Power and Melvin 2008). In the current year, all raw data files were received and the data compared with the edited results before the final analysis was completed. The main reason for these comparisons is to check for target uncertainty, to distinguish fish from bottom and to examine interference/noise patterns. As a result of these examinations, some data problems were identified and resolved by re-editing the data for some vessels and for specific surveys. In a few cases, the bottom was not completely removed or some non-herring species were apparent.

In previous years, vessel noise/interference was apparent in some of the raw data files examined. The solution for future analysis is to have raw data files made available and examined at regular intervals, and at the first sign of problem the source will be determined and corrected, if possible. In addition, the operational vessel speed should be determined for each vessel and surveying speed limited to this. In 2010, noise tests were again completed for each vessel as part of the calibration process, and recommended speed or vessel RPM levels were established. As a result of these efforts, the resulting raw data collected was found to have less background noise and was useable from all survey vessels.

LENGTH/WEIGHT RELATIONSHIP

Prior to 2001, the fish weight variable in the target strength (TS) equation (Table 3) was estimated using a length/weight relationship developed from combined average monthly data for each area. Target strength was estimated using the generic clupeid equation from Foote (1987). A correction factor of 1.02 was also applied to each length measurement to account for the shrinkage of fish due to freezing, prior to calculating the length/weight relationship (Hunt et al. 1986). This relationship was then used to estimate the weight of a fish for a given length. The time window used to select data appropriate for individual surveys has been narrowed since 2001, to provide a more representative estimate of mean fish weight at the time of surveying. Recent initiatives and continued collaboration with the processing plants have greatly improved sampling, such that it is now possible to obtain a significant number of detailed samples (length/weight data) within a nine-day window (four days prior to or after each of the surveys). These data are used to develop a weight/length relationship specific to each acoustic survey (Table 3). The mean length of herring sampled during the night of the survey (or from landings of the previous night) and the calculated mean weight is then used to estimate TS specific to each survey period. When samples were not available, TS was estimated using values for an 'average spawning fish' at 28cm in length with adjustment for sounder frequency as required.

INTEGRATION CALIBRATION FACTOR

In 2003, an option to account for the non-square waveform observed in a ball calibration was incorporated into the Hydroacoustic Data Processing Software (HDPS) (Melvin et al. 2004). This approach is used by several acoustic manufacturers when calibrating their echo sounders. The effect of including an integration calibration factor (ICF or CIF) to estimate backscatter in the integration process varies depending on the vessel's acoustic hardware. The multiplier for the factor, which is applied to the standard calibration, typically lies between 0.4 and 1.6, with 1.0 equivalent to an ideal square wave and thus requires no adjustment.

Given that the inclusion of the CIF is deemed to provide a more accurate estimate of biomass, it was recommended that all future analyses utilize the CIF to calculate absolute biomass (Melvin et al. 2004). However, when comparing observations from year to year, it was recommended that the comparisons be made between biomass estimates that exclude the adjustment, until a time series has been established with the CIF included.

Recalculation of SSB estimates for the earlier years from 1999 to 2002 using the CIF has been partially completed for 2001 and 2002 and the results presented at the 2008 Regional Advisory Process (RAP) meeting. Analysis for the 1999 and 2000 data is ongoing and will be completed in 2012/13.

The current analysis is the first time all results are presented using calculations with only the CIF. Unless otherwise noted, only biomass estimates with the CIF will be referred to when summarizing the data results.

ACOUSTIC SYSTEMS

In 2010, as in previous years, acoustic data were collected using automated logging systems aboard commercial fishing vessels during both standard fishing excursions and structured surveys. The systems, which were activated whenever the captain wished to document observations, automatically saved all data to the system's hard drive. The data were downloaded at regular intervals prior to archiving, data editing and summary analysis.

A total of 18 automated acoustic logging systems (FEMTO model DE9320 or SIMRAD MODEL ES-60) were deployed on commercial fishing vessels in 2010. Systems from FEMTO Electronics were installed and calibrated aboard nine purse seine vessels, *Brunswick Provider, Canada 100, Dual Venture, Island Pride, Lady Janice, Lady Melissa, Lady Noreen, Moon Raker,* and *Silver Harvester.* There were also three SIMRAD ES-60 acoustic systems calibrated and used on the purse seine vessels *Margaret Elizabeth, Morning Star* and the *Leroy & Barry*. There were six FEMTO systems on the inshore herring gillnet vessels *Bradley K, Lady Patricia, Miss Owls Head, Natasha Lee, SKJ* and the *Wet & Wild.*

STRUCTURED SURVEYS

Structured surveys are defined as those surveys that follow the standard protocol described by Melvin and Power (1999). Under this protocol, commercial vessels follow a series of randomly selected transects within a pre-defined area. The number of transects depends upon the number of vessels involved. Acoustic recording vessels are distributed throughout the survey area to provide representative coverage. The surveys conducted periodically throughout the spawning season are generally scheduled at two-week intervals. These surveys play an important role in the understanding and perception of the 4WX herring stock. Sufficient flexibility is built into the process to allow for schedule changes and for investigation of areas of interest or uncertainty. Structured surveys were conducted on each of the major, and several of the minor, spawning grounds within 4WX, and additional recordings were made of both spawning and non-spawning aggregations during fishing night operations.

FISHING EXCURSIONS

Fishing nights are defined as those occasions when acoustic data are collected by fishing vessels equipped with automated acoustic logging systems during the search phase of a fishing excursion. These data, which often do not follow any formal survey design, provide information on the distribution and abundance of herring during non-survey nights. The data have also been used in the past to document large spawning aggregations not included in a survey and/or as a substitute for a survey, in the event that no other information is available. The approach to the activation of the systems has changed since the start of the program. During the early stages, fishing captains would turn their system on when they reached the fishing ground and off once they deployed their fishing gear. For the last few years, the majority of vessels have activated their systems only when they believed there was something worth recording. This has greatly reduced the amount of time required for archiving, editing and analyzing.

Analyses of acoustic data from non-survey nights were possible in previous years due to the provision of technical support from the HSC since 2002. Due to reductions in recent years, data from fishing nights were examined only where sufficient aggregations were surveyed and where established survey protocols were followed. Any fishing night estimate found to be higher than the nearest survey estimate for that spawning area and time period can be considered for the overall area estimates. In 2010, fishing nights were examined but none were considered useful in the final analysis for the overall surveys.

RESULTS

The spawning biomass for individual components of the 4WX herring stock complex in 2010 was estimated from industry collected data using multiple structured acoustic and mapping surveys on major spawning grounds (Figure 1). These surveys, when summed, provide an index of SSB and form the foundation for evaluation of the stock status. The following text provides a summary of the 2010 observations and SSB estimates for each of the main spawning components within the stock complex.

BAY OF FUNDY/SOUTHWEST NOVA SCOTIA (SWNS) SPAWNING COMPONENT

Biological Sampling for Maturity

The timing of surveys in relation to the residence time of spawning groups on the spawning grounds continues to be an issue of major concern. The current hypothesis for surveys on individual spawning grounds assumes that there is constant spawning on each ground over the season with individual spawning groups or waves continuously arriving, spawning and then leaving within 10 to 12 days (or less).

Sampling data for maturity supports the view of continuous spawning or waves with high proportions of ripe and running (Stage 6) fish observed over an extended period. The 10 to 14 day window between surveys also assumes that there will be no double counting and that the maturing (hard/Stage 5), as well as the spawning (Stage 6) fish in the samples will also have spawned and left before the next survey.

In previous years, herring maturity data were obtained from two primary sources: "Herring Roe Analysis Sheet" data from the Scotia Garden Seafood processing plant quality control group and samples from the standard biological sampling program conducted by staff at the St. Andrews Biological Station (SABS). The "Roe Analysis Sheets" from industry were supplied as available, usually on a daily basis during the spawning period and often with multiple samples from different boats. These are random samples of 50 to 100 fish, with the males and females separated, and the individual gonads weighed into categories for use by the processing plant. From these data, the overall percent weights of mature, immature and spent females, as well as percent weight of the male gonads were determined. In 2010, there was some data provided by industry sources but analysis had not been completed.

The SABS biological samples provide data on individual fish for length, weight, sex, maturity stage, gonad weight and age. These samples are collected from various sources including research surveys, tagging trips and acoustic surveys, and from landings at various plants. For comparison with the industry categorization, a modification to the SABS lab procedure to weigh all gonad stages was implemented in 2003. SABS samples were combined for female fish by day and percent numbers and percent weight by the categories determined. The plant classification system of maturity must not be confused with the standardized ICES (International Council for the Exploration of the Sea) scientific scale of 1 to 8 (Parrish and Saville 1965), but the industry roe data can be compared with SABS data based on knowledge of the two methods. Analysis of the roe maturities was completed for the data available on an individual survey basis and is presented with the details for each survey area.

Spawning Ground Turnover Rates

The current acoustic survey method on spawning grounds is dependent on the assumption of periodic turnover of spawning fish.. Acoustic surveys are required to be separated by at least 10 to 14 days to allow for turnover and to prevent double counting (Power et al. 2002). This aspect of the assessment method was the subject of investigation in 2001 and of intensive sampling for maturity stage since that fishing season. The results and application to the acoustic surveys are summarized by Melvin et al. (2002, 2003, 2004), Power et al. (2005, 2006, 2007, 2008) and by Power and Melvin (2010) and were used to assist in the evaluation of turnover timing and the inclusion or exclusion of specific acoustic surveys.

From 1998 to 2002, the Pelagics Research Council/Herring Science Council, in partnership with DFO, tagged herring on spawning grounds and on the major Nova Scotia over-wintering grounds. The information on tags returned from this study has been summarized by Waters and Clark (2005). Evidence from tagging experiments conducted in 1998 of ripe and running (spawning) herring showed that the residence time for most returns on the same grounds was less than seven to ten days; however, 25% of returns were captured on the same grounds after more than 10 days at large (Paul 1999). In contrast, a similar experiment in September 2001 on German Bank showed no recaptures after nine days on the same grounds during the same spawning season (Power et al. 2002). This latter result was complicated by a large decrease in fishing effort (and thus returns) during the second week after tagging.

In response to a recommendation from the 2005 RAP, tags were applied to herring on the spawning grounds of Scots Bay and German Bank (Clark 2007). The results from the tag returns indicated that some tagged herring remained on the spawning grounds for at least three weeks after tagging and, in some cases, up to five to six weeks after tagging. Thus, acoustic surveys that were spaced at two-week intervals were surveying some of the same fish twice or possibly even three times.

These results may have serious implications in how the acoustic surveys are evaluated and used to determine stock status. Some preliminary analysis has been completed comparing three different approaches for the interpretation of the acoustic biomass estimates in an absolute sense (Power et al. 2006). The results showed that caution is warranted when employing the cumulative biomass estimates as absolute in any of the survey areas. The results also indicated that some proportion of herring remain in the survey area even three weeks or longer. However, these adjustments do not change the overall trends over time, but rather apply a scaling to the absolute amounts.

A framework assessment meeting in January 2007 determined that double counting does occur, but the extent has not been well determined (DFO 2007). However, it was still recommended to continue to do surveys at 10 to 14 day intervals to avoid double sampling. The timing/turnover issue was considered to be of highest importance for further study, which should include work on the duration of the maturation process, further tagging with more frequent intervals to estimate turnover rates and increased survey frequency to reflect maturity stage duration.

A tagging experiment to investigate turnover was implemented in 2009 with daily tagging on German Bank from August 18 to September 30 with over 10,000 tags applied (Maxner et al. 2010). The results from this study found that although the majority of the tags were returned by the first three weeks after tagging, some remained on the spawning grounds for up to five weeks. This study has been ongoing annually with tagging on German Bank during the spawning period scheduled to be completed in 2011. Similar results were found when the data were analyzed on a daily, rather than weekly bases, except the percent remaining on the spawning ground decreased slightly due to more precise time interval. The percent of tagged herring remaining after 14 days was 78-87% depending upon the year.

Acoustic Surveys

Scots Bay

The Scots Bay herring purse seine fishery has been an important component of the summer fishery with catches since 1987, ranging from 1,000t to 24,400t during the period of early July to late August-early September (Power et al. 2010). The 2010 Scots Bay fishery was again restricted with a 5,000t cap due to the poor performance of the spawning component since 2005. Landings in 2009 were substantially reduced from 2008, with only 900t caught from July 12 to August 11 (Power et al. 2010).

In 2010, landings in Scots Bay increased to 4,086t, with landing dates from July 9 to September 7. Most of the catches were located within the defined survey box area, but there were substantial catches with 1452t, or 36%, located outside the box either in Advocate Bay or into the upper part of Scots Bay.

Sampling was adequate with samples from most landings allowing detailed description of the size and maturity of fish captured (figures 2, 3). Samples for gonad maturity showed mostly ripe and running (spawning), as well some maturing (Stage 5) stages (Figure 3). Some immature juvenile fish were also picked up from research bottom trawl samples collected in the area from July 10 to 13.

Six structured surveys were conducted during the 2010 spawning season in Scots Bay, which is more than in previous years (Table 2). The surveys, which began about two weeks earlier than the surveys conducted in 2009, were separated by a minimum of 13 days and provided good coverage of the survey area.

Scots Bay Acoustic Survey #1: June 26, 2010

- This was generally a poor survey due to deviations from assigned lines, vessel and sonar noise and lack of data from one boat. The survey was conducted by just three boats, all with acoustic systems, each with two assigned transects at a spacing of about 2.5km within the defined survey box area. Only four lines were completed due to one recording system not being activated until late in the survey (Figure 4).
- There were concerns with two of the boats data due to speed noise and interference from sonar, but these data were not removed from the analysis. In addition, there were several deviations from the lines to document fish without returning to the original point of departure of the assigned line. These deviations can cause a positive bias in the survey estimate and are normally removed in the final analysis if deemed significant.
- The interpretation of some of the acoustic backscatter was questionable with a significant number of very disperse targets of low TS detected which could be either small herring or large mackerel. In addition, the depth distribution, with most of the backscatter well above bottom, did not show thick aggregations near bottom which would indicate spawning fish.
- Sampling data was not available for this survey with the first fishery samples on July 9 (13 days after the survey). Since there are indications that fish were small and non-spawning, the standard TS using 28cm mean length may not be appropriate if this survey is used in the overall annual estimate.
- The initial analysis of 11,136t by A. Clay for the survey area coverage of 430km^2 using standard TS (with CIF) was confirmed and not revised (Table A1).
- Analysis by depth layer for the transects within the survey box area showed 19% of the total biomass in the 0-10m depth zone and 26% above 40m for 2010 compared with 57% and 2% respectively for 2009 (Figure 5a and 5b). The 2010 observations are not characteristic of spawning fish. As a result of the unusual depth distribution and the lack of sampling to confirm maturity, this survey was rejected from the overall total for the area.

Scots Bay Acoustic Survey #2: July 10, 2010

- This was a good survey conducted by six boats, all with acoustic systems. Each boat completed two transects at a spacing of about 1.6km within the defined survey box area for a total coverage of 700km^2 (Figure 6).

- There were concerns with the data from some boats due to speed noise but the data were not removed from the analysis. One boat had changes made to its logging sounder. The data could not be used because the system had not been recalibrated.
- The interpretation of the acoustic backscatter showed targets were relatively uniform in distribution with a lack of significant aggregations except in the northeast corner. The aggregation in the northeast corner is a very small, very dense aggregation of fish on bottom, probably a portion from the larger aggregation found in Advocate Bay later that night.
- Sampling data using fishery samples from (one day before and after the survey) had a mean size of 26.9cm and average weight of 153g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 7).
- Maturity sampling by the fishery showed fish mainly in hard spawning condition (Stage 5) with a range from 58-78%. Research samples were collected at the same time but mainly from outside of the survey box area. A mixture of juvenile and adult stage fish (Figure 3) were observed.
- Initial analysis was completed by A. Clay with an estimate of 18,325t for the entire survey area using standard TS (with CIF). Analysis with revised sample TS resulted in a total biomass of 16,892t. Final analysis with the inbox area of 646km^2 separately from the outer areas with TS from fishery samples gave a total biomass estimate of 17,172t (with CIF) (Table A2).
- Analysis by depth layer for the transects within the survey box area showed 41.6% of the survey biomass was found in the 0-5m depth zone off bottom (Figure 8)
- Additional analysis of fishing night data on schools outside the survey area near Advocate Bay was deemed unusable due to biased lines (turns in fish), a lack of equally spaced straight parallel transects and difficult estimation of school area (Figure 9). A biomass of 4,636t was estimated using the data available for the three areas or schools of fish encountered (Table A3). This estimate was added to the outbox area as a fishing night estimate for July 10.

Scots Bay Acoustic Survey #3: July 24, 2010

- This was a fairly good survey conducted by eight boats, all with acoustic recording systems. Each boat completed two transects at a spacing of about 1.5 to 3.0km within the defined survey box area for a total coverage of 800km^2 (Figure 10).
- There were concerns with the transects from four of eight boats due to issues with not following assigned lines or deviations to document fish off the line without returning to the point of departure (although one boat, the *Margaret Elizabeth* did attempt to do this).
- The interpretation of the acoustic backscatter found no significant aggregations along the lines but rather targets were reasonably uniformly distributed. There were two aggregations located off-track which were documented, but this data were removed from the final transect lines for the overall survey area due to the biasing effect. These schools were estimated separately with a biomass of 2,000t using preliminary spatial analysis.
- Sampling data using fishery samples from July 25-26 (one to two days after the survey) had a mean size of 26.2cm and average weight of 142g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 11).
- Initial analysis was completed by A. Clay with an estimate of 10,564t for the entire survey area using standard TS (with CIF). Analysis with revised sample TS resulted in a biomass of 9,565t. Final analysis with the inbox area coverage of 580km^2 separately from the outer areas with TS from fishery samples gave a total biomass estimate of 9,439t (with CIF) (Table A4).

- Analysis by depth layer for the transects within the survey box area showed the biomass distribution was more evenly distributed in the water column with only 14% in the bottom 5m compared with 42% seen in the previous survey (Figure 12).

Scots Bay Acoustic Survey #4: August 7, 2010

- This was an excellent survey conducted by 12 boats, 11 with acoustic recording systems. Each boat completed two transects at a spacing of about 1.0km within the defined survey box area for a total coverage of 825km^2 (Figure 13). One line was mistakenly completed twice with one vessel steaming up the line and another following down the same line resulting in a gap in the survey spacing completed.
- There were no concerns in this survey with boats not following assigned lines or deviations to document fish off the line without returning to the point of departure. One boat, the *Island Pride* did have an intermittent noise problem apparently due to a poor power supply.
- The interpretation of the acoustic backscatter showed only a few significant aggregations along the lines with most targets thinly and uniformly distributed in the water column.
- Sampling data using fishery samples from August 8-9 (one to two days after the survey) had a mean size of 25.7cm and average weight of 133g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 14).
- Initial analysis was completed by A. Clay, with an estimate of 15,197t for the entire survey area, using standard TS (with CIF). Analysis with revised sample TS resulted in a biomass of 13,300t. Final analysis using the duplicate lines and with the inbox area separated from the outer areas gave a total biomass estimate of 13,528t (with CIF) (Table A5). Note that removing one or the other of the duplicate lines would only reduce the estimate by 200t.
- Analysis by depth layer for the transects within the survey box area showed 51.9% in the first 15m off bottom and about 40% greater than 30m above bottom (Figure 15).

Scots Bay Acoustic Survey #5: August 21, 2010

- This was a good survey conducted by five boats with acoustic recording systems. Each boat completed two transects at a spacing of about 1.5km within the defined survey box area for a total coverage of 640km^2 (Figure 16).
- There were no concerns in this survey with boats not following assigned lines or deviations to document fish off the line without returning to the point of departure. The *Moon Raker,* however, did not turn off its sonar making the data practically unusable due to interference.
- The interpretation of the acoustic backscatter showed only a few significant aggregations along the lines with most targets thinly and uniformly distributed in the water column.
- Sampling data using fishery samples from August 22-23 (one to two days after the survey) had a mean size of 25.4cm and average weight of 122g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 17).
- Maturity samples confirmed that fish caught in the area had mature roe in spawning condition with a mixture of hard (Stage 5) and ripe/running (Stage 6).
- Initial analysis was completed by A. Clay with an estimate of 9,724t for the entire survey area using standard TS (with CIF). Analysis with revised sample TS resulted in a biomass of 8,037t. Final analysis with the inbox area coverage of 540km^2 separately from the outer areas with TS from fishery samples gave a total biomass estimate of 8,011t (with CIF) (Table A6).

- Analysis by depth layer for the transects within the survey box area showed 58% in the first 20m off bottom which is more dispersed than seen in previous surveys (Figure 18).

Scots Bay Acoustic Survey #6: September 5, 2010

- This was a good survey conducted by five boats with acoustic recording systems. Each boat completed two transects at a spacing of about 1.6km within the defined survey area for a total coverage of 660km^2 (Figure 19).
- There were no concerns in this survey with boats not following assigned lines or deviations to document fish off the line. There appeared to be issues with editing the *Lady Patricia* and *Morning Star* data due to sonar noise (blocky edits) and poor bottom resolution with the *Lady Patricia*.
- The interpretation of the acoustic backscatter showed a significant portion of the biomass detected and reported seemed to be from juveniles as seen from the TS distribution. An analysis of the *Margaret Elizabeth* data (not included) produced a bimodal distribution of 11cm and 27cm targets, but this result was not used to adjust the final estimate.
- Sampling data using fishery samples from September 6 (one day after the survey) had a mean size of 25.8cm and average weight of 132g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 20).
- Maturity samples from landings on September 6 confirmed that fish caught in the area had mature roe with a mixture of 59% hard (Stage 5) and 36% ripe/running (Stage 6).
- Initial analysis was completed by A. Clay with an estimate of 1,499t for the entire survey area using standard TS (with CIF). Analysis with revised sample TS resulted in a biomass of 1,290t. Final analysis with the inbox area coverage of 560km^2 separately from the outer areas with TS from fishery samples gave a total biomass estimate of 1,238t (with CIF) (Table A7).
- Analysis by depth layer for the transects within the survey box area showed the backscatter was more evenly dispersed than most surveys with 46% in the first 20m off bottom (Figure 21).

2009 Scots Bay Summary

The 2009 Scots Bay acoustic survey SSB estimate from the five structured surveys for the within survey box area (inbox) was 81,645t as calculated with the CIF. For 2009, the total biomass estimate for areas surveyed outside of the standard survey box in the Scots Bay area was 6,112t with the CIF. The lack of biological sampling and early timing of the first survey on June 27, 2009, called into question it's validity in the overall estimate, but it remained included in the overall total for the area in 2009. Re-examination of the June 27, 2009, survey using the new depth layer analysis confirmed that the fish depth distribution indicated spawning fish and so the survey biomass remained in the overall estimate for the year.

2010 Scots Bay Summary

The early timing of the first survey on June 26, 2010, distribution of targets in the upper water column and preliminary analysis of TS indicating small fish called into question the validity of this survey and so was excluded from the overall total. There was also a lack of biological sampling or catches for this survey.

The 2010 Scots Bay acoustic survey SSB estimate from the six structured surveys for the within survey box area (inbox) was 42,290t (with CIF). The total biomass estimate for areas surveyed outside of the standard survey box in the Scots Bay area was 7,098t from surveys and 4,636t was added for one fishing night on July 10 with a total outbox SSB of 11,734t. The final 2010 Scots Bay acoustic survey estimate for all areas was 54,023t with CIF (Table 4).

German Bank

The German Bank herring purse seine fishery has been a major component of the summer fishery with catches since 1985, ranging from 9,000t to 36,000t during the overall fishery period of early May to late October (Power et al. 2010). Catches during the spawning period in 2008 were distributed quite differently from those of 2007, with only a single central area of spawning catch concentration in the upper middle part of the area (Power et al. 2010). In 2009, catches of spawning herring were more widespread with localized groups seen in both the northern and southern portions of the standard survey area on German Bank (Power et al. 2010).

In 2010, catches on German Bank were similar in distribution to those of 2009 with 17,491t reported from within the survey box area over the entire year.

Eight acoustic surveys were conducted on German Bank during the 2010 season between August 18 and October 26 covering the entire spawning period (Table 2). The time interval between surveys ranged from 7 to 14 days, and a total of 62 vessel nights of surveying were completed for the German Bank area (Table 2). In addition to the acoustic recordings, visual observations from the sounder were recorded at 5-10 minute intervals on deck sheets for all vessels.

Fish samples for maturity indicated that mature spawning herring (Stages 5-6) dominated samples collected, although immature juvenile herring were collected in the spawning box area by the CCGS *Alfred Needler* between August 28 and September 2 (Figure 22). As in previous years, length sampling was very extensive for this fishery with fish sampled from within the survey box found to be mostly larger than 23cm, which is the approximate size of 50% maturity for first spawning in this stock (Figure 23a, 23b). Pre-spawning herring of less than 23cm were infrequent in 2009 but were occasionally high, indicating there was a mixture of juvenile and adult fish available on the grounds on some occasions.

German Bank Acoustic Survey #1: August 19, 2010

- Excellent survey conducted by eight acoustic survey vessels with a total of 16 transects spaced at about 1.2km within the defined survey box area (Figure 24).
- Initial analysis by A. Clay with overall 95,480t (standard TS for 28cm, larger area, no *Island Pride* data, with CIF). A rerun using the same analysis with the sample adjusted TS gave a result of 85,734t.
- Re-cut the transects to be inside or outside the standard survey box; fixed *Island Pride* navigation and re-edited data so it was now included.
- Sampling data using fishery samples collected on August 18-19 with a mean size of 27.0cm and average weight of 150g were used for final TS calculation with adjustment for frequency of the echo sounder (Figure 25).
- Final estimate of 85,150t (calculated with CIF) for the total area combined using a standard area of 646km^2 for in-box and estimated outbox area as 25km^2 (Table A8).
- Analysis by depth layer for transects within the survey box area showed 69.2% of the total area backscattering strength (Sa) was found within the first 10m off bottom with 32.2% in the zone 1-2m off bottom alone (Figure 26).

German Bank Acoustic Survey #2: August 31, 2010

- Good survey conducted by eight survey vessels (seven with recording systems) for a total of 14 acoustic transects spaced at about 1.2km (Figure 27). Two transects were west of the main survey box area and the inner lines were done by a mapping boat. Editing of questionable bottom/fish for *Tasha Marie* line was rejected as being fish and data for the *Dual Venture* was used despite uncertainty about its sounder settings.
- Sampling data from fishery on September 1-2 had a mean size of 27.2cm and average weight of 144g, which was used for final TS calculation with adjustments for frequency (Figure 28).
- Sampling data from *CCGS Alfred Needler* midwater trawl in the same period near the main spawning area showed smaller fish in the midwater layer (Figure 29). If these samples were used for TS and then for biomass estimate would be reduced substantially.
- Since the entire area was covered by both acoustic and mapping boats, the standard area of 646km^2 was used for the inbox area with substitution of an adjacent lower density line for the mapping boat which recorded only small amounts of fish.
- Initial analysis by A. Clay of 69,019t (with CIF) using standard TS based on mean 28cm/180g fish. A rerun using the same analysis with the sample adjusted TS gave a result of 58,456t or a decrease of 10,563t due to sampling alone.
- Final estimate of 58,570t (calculated with CIF) for the total area combined using fishery samples for TS (Table A9).
- Layer analysis showed 85% of the biomass came from the bottom 5m and 42% of the total biomass was within the layer 1-2m off bottom (Figure 30).

German Bank Acoustic Survey #3: September 8, 2010

- This was a good survey conducted by nine acoustic survey vessels with a total of 14 of 18 useable transects spaced at about 1.0km (Figure 31). There were gaps in spacing due to transect exclusion and the use of a mapping boat.
- Data from the *Morning Star* was excluded due to sonar interference. Data from the *Dual Venture* was very difficult to separate from bottom due to sounder saturation and was also excluded. Data from the *Island Pride* had noise interference problems but was used with shortened transects.
- Sampling data using fishery samples collected on September 8-9 with a mean size of 26.8cm and average weight of 141g was used for TS calculation with adjustment for frequency of the echo sounder (Figure 32).
- Initial analysis of 76,452t by A. Clay used standard TS for a 28cm fish for a single combined area. When the sample TS was applied the result was 65,550t.
- Final total estimate of 66,839t with separation for in-box and out-box areas (calculated with CIF) for analysis excluding both the *Morning Star* and the *Dual Venture* data (Table A10).
- Analysis by depth layer for transects within the survey box area showed 74% of the total biomass was found within the zone 0-5m off bottom with 33% in the 1-2m depth zone alone (Figure 33).

German Bank Acoustic Survey #4: September 15, 2010

- This was a good survey conducted by nine boats with acoustic systems and one mapping vessel with a total of 16 useable transects spaced at about 1km within the defined survey box area (Figure 34). There was a 2km gap in the line spacing due to the use of the mapping survey boat.

- Data from the *Island Pride* was excluded due to severe noise interference problems. There were also concerns with some boat data due to sonar noise and interference due to speed but these data were not removed from the analysis.
- Sampling data using fishery samples collected on September 14-15, with a mean size of 26.4cm and average weight of 133g, was used in TS calculation with adjustment for frequency of the echo sounder (Figure 35). There were no fishery samples within seven days available for the southern aggregation seen during the survey.
- Initial analysis of 75,863t by A. Clay for the overall area (standard TS for 28cm, with CIF and *Island Pride* data excluded). When fishery sample TS is included the result was 63,000t.
- Final total biomass estimate of 65,230t (calculated with CIF) for the overall area with the *Island Pride* data excluded (Table A11).
- Analysis by depth layer for transects within the survey box area showed 57% of the total biomass was found within the zone 0-5m off bottom with 21% in the 1-2m depth zone alone (Figure 36).

German Bank Acoustic Survey #5: September 23, 2010

- This was a good survey conducted by seven boats, all with acoustic systems. Each boat completed a single transect at a spacing of about 1.6km within the defined survey box area for an area coverage of 425km^2 (Figure 37).
- There were concerns with some boat data due to sonar noise and interference due to speed but these data were not removed from the analysis. Two boats also made slight deviations from their assigned lines to document fish but there was no adjustment made for this.
- Sampling data using fishery samples collected on September 24, from successful fishing after the survey was completed, had a mean size of 26.7cm and average weight of 137g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 38).
- Initial analysis of 19,908t by A. Clay for the overall area (standard TS for 28cm, with CIF). Final total biomass estimate of 16,637t (calculated with CIF) for the surveyed area of 425km^2 when fishery sample TS is included (Table A12).
- Analysis by depth layer for transects within the survey box area showed a more even distribution by depth than previous surveys with 25% of the total biomass within the zone 0-5m off bottom and only 7% in the 1-2m depth zone (Figure 39).

German Bank Acoustic Survey #6: October 5, 2010

- This was a good survey conducted by nine boats, all with acoustic systems. Each boat completed a single transect at a wider than usual spacing of about 2.2km for an overall area coverage of 870km^2 (Figure 40).
- There were concerns with one boat data due to sonar noise, but these data were not removed from the analysis. The *Lady Noreen*, on the western-most line, recorded unusual 'balls' on bottom which were closely reviewed, and most were rejected as being fish. Even after re-editing, these data had a significant effect on the biomass estimate for the 'out-box' area.
- Sampling data using October 6 fishery samples from successful fishing after the survey had a mean size of 26.7cm and average weight of 138g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 41).

- Initial analysis by A. Clay of 53,064t using un-revised *Lady Noreen* data (overall area; standard TS; with CIF). Analysis with sample TS gave an estimate of 44,513t.
- The final analysis (using revised re-edited *Lady Noreen* data) with lines separated between 'in-box' and 'out-box' areas had a total biomass estimate of 36,068t (calculated with CIF) for the combined surveyed area using fishery sample TS (Table A13).
- An excellent line grid was also completed after the main survey on a school located mostly between transects (Figure 42). The biomass for the school alone was estimated at between 3,200t and 5,300t depending on the combination of transects used (Table A14). Since the school was within the overall survey area it was not added to the total biomass estimate.
- Analysis by depth layer for transects within the survey box area showed 55% of the total biomass was found within the zone 0-5m off bottom with a peak of 18% in the 3-4m depth zone (Figure 43).

German Bank Acoustic Survey #7: October 19, 2010

- This was a good survey conducted by seven boats, all with acoustic systems. Each boat completed a single transect at a spacing of about 3.2km with an expanded total survey area coverage of 875km^2 (Figure 44).
- There were concerns with some boats data due to sonar noise, but the data were not removed from the analysis. In addition, there were concerns with the interpretation of the acoustic backscatter. The results may be an overestimate of the resource because much of the backscatter does not appear to be typical herring aggregations. In addition, the depth distribution of the backscatter, with 36% of the biomass more than 50m off bottom, did not show thick aggregations near bottom, which would indicate spawning fish.
- Sampling data using fishery samples from October 14 (five days before the survey) on the last successful fishing before the survey had a mean size of 26.7cm and average weight of 138g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 45).
- Initial analysis of 10,132t by A. Clay for the overall area (standard TS for 28cm, with CIF). Analysis with revised sample TS resulted in an estimate of 8,526t. Final analysis with the inbox and outbox areas combined gave a total biomass estimate of 8,721t (calculated with CIF) for the overall area using TS based on fishery samples on October 14 (Table A15).
- Analysis by depth layer for the transects within the survey box area showed 36% of the total biomass was found within the upper part of the water column above 50m with only 10% in the 0-5mm depth zone (Figure 46).

German Bank Acoustic Survey #8: October 26, 2010

- This was a good survey conducted by five boats, all with acoustic systems. Each boat completed two transects at a spacing of about 1.6km within the defined survey box area for a total coverage of 646km^2 (Figure 47).
- There were concerns with some boats data due to speed noise, but the data were not removed from the analysis. The *Morning Star* data was found to be 'weak' and intermittent with breaks in the files, but was used without adjustment.
- The interpretation of the acoustic backscatter was questionable. The results may be an overestimate of the resource because much of the backscatter does not appear to be typical herring aggregations. In addition, the depth distribution, with most of the backscatter in the upper water column, did not show thick aggregations near bottom which would indicate spawning fish.

- Sampling data using fishery samples from October 14 (12 days before the survey) on the last successful fishing night had a mean size of 26.7cm and average weight of 138g. These samples were used in TS calculation with adjustment for frequency of the echo sounder (Figure 45).
- Initial analysis of 4,497t by A. Clay for the survey area using standard TS for 28cm (with CIF). Analysis with revised sample TS resulted in an estimate of 3,784t. Final analysis of the inbox area of 646km^2 with TS from fishery samples gave a biomass estimate of 3,820t (calculated with CIF) (Table A16).
- Analysis by depth layer for the transects within the survey box area showed 47% of the total biomass was found within the upper part of the water column above 50m, with only 5% in the 0-5m depth zone (Figure 48).
- This estimate was not used in the overall total for German Bank due to the lack of sampling and the distribution of biomass by depth, which was not typical of spawning fish near bottom.

German Bank Summary

In 2008, the overall German Bank spawning stock biomass (without the integration factor) was estimated to be 201,700t from four structured surveys covering a period extending from August 22 to October 6.

In 2009, the overall German Bank biomass was estimated to be 308,713t using five of seven structured surveys covering a period extending from August 12 to October 20 (September 8 survey was replaced with that of September 14, and the October 20 survey was not included in the total).

In 2010, the overall German Bank biomass was estimated to be 253,768t using seven of eight structured surveys covering a period extending from August 18 to October 16 (Table 5). The September 8 and September 23 surveys were removed due to survey intervals of less than ten days, and the October 26 survey was not included in the total.

Spectacle Buoy

The spring gillnet fishery for roe has occurred in recent years for a short period in June in the vicinity of Spectacle Buoy located just southwest of Yarmouth, Nova Scotia. The fishery is dependent upon the availability of fish and to some extent market conditions, and may or may not occur in any given year. In 2008, there was virtually no fishery with only one landing of 6t. Two acoustic surveys were undertaken in 2008 but very little fish was recorded. In previous years, herring in this area were believed to have occurred in greater abundance in late May-early June, and it is assumed the surveys had missed the majority of fish but there were no other signs or reports of herring in 2008.

In 2009, there was little fishing (less than 1t) and no survey activity in this area.

In 2010, there were no catches reported (Table 6). Three surveys completed on June 2, June 4 and June 17 (figures 49-51) with biomass estimates of 1,548t, 421t and 3,11t (Table 7). The June 4 survey was excluded due to the timing interval of only two days for an overall total SSB of 1,859t (Table 7).

Trinity Ledge

In previous years, the surveying of spawning herring on Trinity Ledge has been considered to be less than optimal, and it is unlikely that biomass estimates accurately reflect the abundance of fish in this area (Power et al. 2007). Improvements to the survey approach and adherence to the design protocols are required if the data are to reflect trends in abundance.

In 2008, three acoustic surveys were undertaken near the Trinity Ledge area on August 2, September 22 and September 24. For each acoustic survey, the single recording vessel documented small areas of herring near the Ledge with biomass estimates of less than 500t. The 2008 total biomass of 520t was the lowest recorded since acoustic surveying began in 1998.

In 2009, catches were again very limited with only 117t recorded between September 1 to September 11. In 2009, two surveys were conducted on Trinity Ledge on August 25 and September 8, with small areas or separate schools of fish documented in each case. The total overall survey biomass for Trinity Ledge in 2009 was 675t as calculated with the CIF.

In 2010, catches of 202t were recorded from August 11 to September 24 (Table 6; Figure 56). Fishery sampling was limited with two samples reported (figures 52, 53). Two acoustic surveys were conducted on Trinity Ledge on August 19 and August 29, with small areas or separate schools of fish documented in each case (figures 54, 55). The total overall survey biomass for Trinity Ledge in 2010 was 2,405t as calculated with the CIF (Table 8).

Browns Bank

There was no survey activity on Browns Bank.

Seal Island

Historically, the spawning areas around Seal Island made a significant contribution to the biomass of the Bay of Fundy/SWNS stock complex. In recent years, the abundance of herring and the documentation of spawning fish in this area have been intermittent. In addition, little fishing has occurred in these shallow grounds, partly as a result of the deep purse seines that are now being employed, which are unsuitable for fishing these areas. There was no survey activity in the vicinity of Seal Island.

Bay of Fundy/Southwest Nova Scotia (SWNS) Summary

Since 1997, biomass estimates determined from acoustic surveys have been used to evaluate the status of the Bay of Fundy/SWNS component of the 4WX herring stock complex. During this time, the approach for estimating SSB has evolved from a heavy reliance on distribution and abundance estimates from fishing excursions with a 10 day minimum elapsed time, to structured surveys scheduled at two-week intervals. In 1999, spawning areas were defined and survey protocols were established to make the estimates more representative of the actual SSB rather than a minimum observed value. This was accomplished by undertaking a series of surveys that covered most of the spawning area on each of the spawning grounds during the defined spawning season. In the absence of survey data, some fishing excursion data may be substituted to obtain a biomass estimate if appropriate.

The SSB for the Bay of Fundy/SWNS component of the 4WX herring stock complex in 2010 was determined from industry based acoustic surveys of the three major spawning components:

Scots Bay, Trinity Ledge and German Bank. Historical timing of surveys and biomass estimates for Scots and German Bank are presented in tables 57 and 58. No structured surveys were conducted outside the main spawning areas, around Seal Island or in the vicinity of Browns Bank. Acoustic data from fishing nights were not included in the biomass estimate for any of the spawning components. No fishing and survey activity took place in the Spectacle Buoy area during the spring spawning period.

For 2009, the majority of acoustic surveys in the Bay of Fundy/SWNS areas were well organized and provided good coverage of the spawning grounds. The elapsed time between all surveys was within the 10 to 14 day guideline and turnover of spawning herring was assumed to be 100% for this analysis. The survey vessels generally completed the assigned transects, and automated recording systems were distributed throughout the fleet on survey nights. The set of surveys for the overall areas is considered to be comparable to others in the series since 1999. Biomass estimates from 1997 and 1998 are not considered comparable due to variation in the coverage area.

The 2010 acoustic results provide an estimate of herring present at the time of surveying when conducted according to the survey design. A major source of uncertainty continues to be the assumption that the surveys are simply additive. If herring do not move on and off the spawning grounds in waves with a short period of time (days) between the waves, the estimate of total SSB will be significantly biased upward due to double counting. The issue of turn-over time and potential overlap (multiple counting) was evaluated at the RAP Framework review meetings in 2006/07 (DFO 2007) and the 10 to 14 day time period between surveys was considered reasonable, but required further investigations. The latest investigation into turnover using tagging studies is presented by Maxner et al. (2010) summarizes the 2010 German Bank turn-over tagging experiment results.

The SSB for Scots Bay reached a high of 163,900t in 2001, showed a major decline in 2005 (Figure 59), likely due in part to the excessive catches of 2004 and 2005 (Power et al. 2010). Since the low in 2005, Scots Bay has shown a slight improvement increasing from 21,200t to 52,700t in 2007. In 2008, there was a substantial decline with an area estimate of 23,400t (Table 9). In 2009, the surveyed biomass increased to 87,700t, but declined again in 2010 to 54,000t well below the 1999-2008 average. There is some question about the inclusion of the first survey of 11,136t on June 26. The lack of sampling to confirm size and maturity and the fact that this survey was two weeks earlier than usual call into question the validity of using this result in the overall total. It was not use in the total biomass estimate for the Scots Bay spawning area.

The total German Bank biomass was estimated to be 253,800t from five structured surveys for 2010. Surveys covered the period from August 18 to October 26, although not all surveys were used in the final estimate (Table 5). The 2010 German Bank spawning biomass estimate represents a decrease of 143,800t (or 36%).

An increase in spawning biomass was observed on Trinity ledge in 2010, although it is well below the 2001-2010 average of 8220t (Table 9). The single recording vessel tended to concentrate on two small aggregations east of the ledge encompassing of < 5km^2. Total observed biomass was 2,0405t (Table 8). Trinity Ledge once supported a large spawning component and fishery within the 4WX stock complex. As such, given the fact that the observed biomass is still low, any fishing on Trinity Ledge must strictly adhere to the "survey, assess, then fish" protocol during the upcoming spawning season. This means that no fishing should occur until sufficient quantities of herring are observed to allow for removals. Alternatively, given the

slow rate of recovery, consideration should also be given to complete closure until a significant increase in spawning biomass is observed.
Surveys around Spectacle Buoy are intermittent and only occur when herring are discovered in the area. The last survey prior to 2010 was conducted in 2007 when only 300t were observed (Table 9). The 2010 biomass of 1,859t was derived from 32 valid surveys conducted in June (Table 7).

The lowest total SSB for the Bay of Fundy/SWNS spawning complex in the time series was estimated to be 301,100t in 2005 (Table 9; Figure 60). Since then, the total SSB has fluctuated between 300,000t and 500,000t, with the 2010 estimated biomass the second lowest in the time series at 312,100t. This represents a decline of 36% from 2009 to 2010, even with an industry imposed catch restriction of 5,000t in Scots Bay. Caution is warranted in establishing removals for this stock component as spawning biomass is deemed to be at a relatively low level.

COASTAL NOVA SCOTIA SPAWNING COMPONENT

The shallow inshore waters of the bays and inlets along the Atlantic coast of Nova Scotia support a number of herring spawning populations. Several documents describe reports of coastal spawning in 4VWX (Clark et al. 1999; Crawford 1979). Direct knowledge of these relatively small coastal populations is limited to a few areas where there are active commercial fisheries for roe on spawning grounds. A traditional fishery for lobster bait occurs in the spring and summer of the year. In the fall, commercial roe fisheries have been conducted in three areas of the Nova Scotia coastal stock component: Port Mouton/Little Hope, Halifax/Eastern Shore and Glace Bay. Surveys of the spawning grounds were undertaken using both the mapping and the structured acoustic survey approach, depending upon the area and the availability of a recording vessel.

The results for each spawning area presented below are calculated only with the CIF, which is considered to provide a more accurate representation of biomass. This method of calculation has been applied since 2003 and can now be used for the consistent calculation of five year averages, which are used to establish beginning of year allocations for each area.

Little Hope/Port Mouton

The 2010 herring gillnet fishery in Little Hope/Port Mouton area began on September 15 and extended to October 14. The total catch of 3,107t in 2010 represents a decrease from 3,730t in 2009 (Figure 61), with the majority of the catch occurring between September 19 and October 17 (Figure 62). The catches occurred in three main areas off Port Mouton, near Liverpool and Port Medway (Figure 63). Overall, five acoustics surveys were conducted in the Little Hope/Port Mouton area between September 21 and October 25. All data were downloaded from the two boats with an acoustic recorder and, after editing to remove the bottom and non-herring targets, the acoustic files were cut into transects for each survey.

Given that the multi-panel gillnet was not used for all surveys to sample the acoustic targets in 2010, the standard TS of -35.96 for a 120 kHz system was used for all surveys where direct samples were not available to estimate biomass from the backscatter. Length frequency and biological samples from the commercial catch were only used to confirm the size and maturity of herring in the area (figures 64, 65). The lack of good sampling for acoustic surveys in this area remains a problem that needs to be corrected. The use of standard TS likely underestimates the average size of herring surveyed with acoustics and may also underestimate the overall biomass.

Little Hope Acoustic Survey #1 - September 21, 2010

The first survey in 2009 for the Little Hope spawning area was conducted by a single acoustic survey vessel, as well as nine vessels doing a mapping survey (Figure 66). The mapping survey vessels used paper data sheets to record observations from their sounders. They covered more of the area than was covered by the acoustic survey vessel, but did not find any additional aggregations. The single acoustic vessel conducted separate fine scale systematic parallel transect surveys over 12 aggregations scattered throughout the spawning box (Figure 66). The transects were not predefined by a survey design but rather were conceived based on the best coverage of the aggregations using parallel lines closely spaced together.

No multi-mesh experimental gillnet samples were collected for length frequency so biomass estimates are based on standard TS for a 28cm fish. The size and maturity of herring from the commercial roe fishery in the area later confirmed the presence of spawning fish in the area. The total biomass from the schools surveyed was estimated to be 26,687t as calculated with CIF and excluding survey which did not meet the elapsed time requirement (tables 10, A17).

Little Hope Acoustic Survey #2 – October 3, 2010

The second herring acoustic survey in 2010 for the Little Hope spawning area was conducted with two acoustic survey vessels. The acoustic vessels conducted separate fine scale systematic parallel transect surveys in fewer distinct areas than the previous survey (Figure 67). The fish were quite light to bottom so results may vary among persons performing the data editing. The vessel saw fewer aggregations of fish with good overall coverage. There was also a mapping survey by gillnet vessels using paper data sheets to record observations from their sounders. They covered more of the area than was covered by the acoustic survey vessels but did not find any additional aggregations (Figure 67).

No samples were collected for length frequency so biomass estimates are based on standard TS for a 28cm fish. The size and maturity of herring from the commercial roe fishery in the area later confirmed the presence of spawning fish (figures 64, 65). The total biomass surveyed was estimated to be 2,044t as calculated with the CIF (tables 10, A18). This survey was not used in the estimate of total spawning stock biomass due to its close timing with survey #3.

Little Hope Acoustic Survey #3 – October 11, 2010

The third acoustic survey in 2010 for the Little Hope spawning area was conducted by two acoustic survey vessels. The vessels conducted four separate fine scale systematic parallel transect surveys (Figure 67). The lines were not predefined by a survey design but rather were conceived based on the best coverage of the aggregations. The fish were also quite dispersed throughout the survey period. The speed of the vessels was good yielding a clear echogram.

This was the first and only 2010 survey for which biological samples were collected using the multi-panel gillnet for length frequency and maturity to confirm spawning condition (Figure 68). Biomass estimates were based on TS for a mean length of 28.9cm fish. The size and maturity of herring from the commercial roe fishery in the area also confirmed the presence of spawning fish (figures 64, 65). The total biomass from the schools surveyed was estimated to be 13,614t with the CIF (tables 10, A19).

Little Hope Acoustic Survey #4 - October 19, 2010

The fourth survey for the Little Hope spawning area was conducted by two acoustic survey vessels. The acoustic vessels conducted six separate fine scale systematic parallel transect surveys over the entire area (Figure 69). No biological samples were available to estimate TS so the standard TS for a 28cm herring was used. The size and maturity of herring from the commercial roe fishery in the area later confirmed the presence of spawning fish (figures 64, 65).

The biomass estimate for the survey was 9,305t (tables 10, A20). Unfortunately, insufficient time (seven days) had elapsed between this and the previous survey for the estimate to be considered new spawning. The biomass from survey #4 was not included in the total spawning biomass for Little Hope.

Little Hope Acoustic Survey #5 - October 25, 2010

The fifth and final acoustic survey for the Little Hope spawning area was conducted by a single acoustic survey vessel. This encountered two small aggregations of spawning herring separated by about 3km within the survey box (Figure 70). The survey was part of a broad scale paper survey with several non-recording boats. The mapping survey used paper data sheets as usual to record observations from the sounders. The non-recording boats assisted the acoustic vessel in locating herring aggregations. The acoustic vessel conducted only two separate fine scale systematic parallel transect surveys over the entire area (Figure 70).

This survey was conducted only six days after the survey of October 19 because the latter survey was excluded from the total biomass estimate and spawning fish were still being observed on the spawning grounds. No samples were collected for length frequency so biomass estimates are based on standard TS for a 28cm fish. The size and maturity of herring from the commercial roe fishery in the area later confirmed the presence of spawning fish (figures 64, 65).

The total biomass from the two schools surveyed was estimated to be 1,327t as calculated with the CIF (tables 10, A21). The results from this survey were included in the total SSB estimate.

Little Hope Summary

In 2010, five acoustic surveys were conducted in the Little Hope/Port Mouton spawning box over the traditional spawning period. The standard protocol for surveying spawning herring of allowing 10 to 14 days between surveys was followed in order to avoid double counting that may have remained from the previous surveys. Using this criterion, only three of the surveys were considered for estimating the total SSB. The second survey was excluded because of its proximity to the third survey which observed substantially more herring than the second. Survey #4 was rejected because only eight days had elapsed between survey #3. The final survey of 2010 was included in the total spawning biomass estimate.

Summing the biomass from all surveys/schools resulted in a total spawning biomass of 26,687t (Table 10), which was about 10,000t less than the 36,588t estimated in 2009 and just above the long term average of 25,900t. The spawning biomass in the Little Hope spawning box now appears to around the long term average, but improved from the low in 2007 (Figure 71).

There are, however, several remaining issues with survey methods and protocols for the Little Hope area that need to be addressed in the coming season. The first, and long standing, issue applies to obtaining good multi-panel gillnet samples to better estimate the size and maturities of the herring being surveyed. A second issue is the extent of the survey area and what should be considered valid as part of the overall biomass estimate for the season. Biomass estimates are based on only fish observed in the spawning box.

Halifax/Eastern Shore Fishery and Surveys

The 2010 herring gillnet fishery in the Eastern Shore fishing area began on September 13 and ended on October 13 with total landings of 2,456t compared with 6,045t in 2009 (Table 14; Figure 72). Landings were low and similar to 2008, which was the lowest since 2002. The decrease in landings was due to difficulty in catching the fish and availability. The fishery began on the same date but was approximately two weeks shorter due to fish and weather. Most catches occurred between September 23 and Sept 28 (Figure 73). Once again, this was primarily a herring roe fishery with catches reported from three main areas: near Halifax Harbour approaches, southwest of Jeddore Head and south of Ship Harbour. Unlike 2009 where catches were well distributed throughout the spawning box, catches were concentrated near the approaches to Halifax Harbour south of Ship Harbour (Figure 74). Surveys were completed in each of the primary fishing areas from Halifax Harbour to near Ship Harbour, Nova Scotia, on September 26, October 4, October 5, October 12 and October 20 (Table 11). The data were downloaded from the two boats with acoustic recorders, *Bradley K* and *Miss Owls Head.* Sampling was good in 2010, for most surveys, with two multi-panel gillnet samples collected over the course of the season for determination of the full range of size and maturity of the acoustically surveyed fish when fish were available. The maturity samples showed a high proportion of ripe and running (Stage 6) fish ranging from 87 to 100% at the time of each survey (Figure 75). Sampling for size using fishery nets with 2¾" mesh and multi-panel nets with mesh sizes of 1⅞", 2⅜", 2½" and 2¾" showed the presence of fish smaller than 30cm early in the season but less so after October 10 (figures 78, 80).

Halifax/Eastern Shore Acoustic Survey #1 - September 26, 2010

The first survey for the 2010 season was conducted by two acoustic survey vessels, the *Bradley K* and the *Miss Owls Head,* although only the *Miss Owls Head* observed and surveyed herring (Figure 77; Table A22). The lines were not predefined by a survey design, but rather were conceived based on the best coverage of the aggregations using equally spaced parallel lines. Only a single school was observed and surveyed in the western section of the survey box school (Figure 77). The entire survey box was covered by 14 non-recording vessels, but no significant amounts of herring were observed elsewhere.

A multi-panel gillnet sample for the western school was taken and processed for both maturity stage and size (Figure 78). The overall size caught ranged from 25.5 to 34cm, with 70% larger than 30cm. The mean length of herring from the multi-panel net with panel mesh sizes from 1⅞"to 2¾" was used for the calculation of TS. Nearly all fish sampled (86%) were found to be in ripe and running spawning condition (Stage 6) (Figure 75). The total spawning biomass from the single school surveyed was estimated to be 13,021t as calculated with the CIF (tables 11, A22).

Halifax/Eastern Shore Acoustic Survey #2 - October 4-5, 2010

This survey was conducted over a two day period approximately 10 days after the first survey by two acoustic survey vessels, the *Bradley K* and the *Miss Owls Head.* The vessels conducted a fine scale systematic parallel transect survey on three aggregations of spawning herring; two schools in the eastern portion and one in the western region of the spawning box (Figure 79). The coverage of the observed aggregations was an excellent example of survey design for a school and how the protocols are to be applied. The average herring density for this transect was estimated as 7.0kg/m^2, which was low compared with 2009 (Table A23). A multi-panel sample was collected and saved (Figure 80). The multi-panel net primarily caught fish from 31 to 34cm in the panel mesh sizes 2½" and 2¾" although there were some smaller fish from 25 to 30cm caught by the smaller mesh panels. The mean length of 30.4cm for the combined panels was used for the calculation of TS. Most fish sampled (87%) were found to be in ripe and running spawning condition (Stage 6), although some (13%) were still in hard roe condition (Stage 5) (Figure 75).

The total biomass from the three schools surveyed on September 24 was estimated to be 7,935t as calculated with the CIF (tables 11, A23).

Halifax/Eastern Shore Acoustic Survey #3 – October 12, 2010

The third survey conducted on October 12 found only a single aggregation of spawning herring south of Jeddore. This third survey was undertaken only seven days after the second survey by a single acoustic survey vessels with one fine scale systematic parallel transect surveys completed on a school of herring (Figure 81; Table A24). The lines were not predefined by a survey design, but rather were conceived based on the best coverage of the aggregations. The single school (#1) was well surveyed by the *Miss Owls Head* with seven transects completed over the 0.75km^2 area. Given the absence of observed fish no mapping boats were involved in the survey (Table 2). No multi-panel samples were collected during the third survey, and biomass estimates were based on the standard 28cm herring with a TS adjustment for frequency. The biomass estimate for the single school was 449t, however, given that insufficient time had elapsed between surveys, this estimate was not included in the total spawning biomass. (tables 11, A24).

Halifax/Eastern Shore Acoustic Survey #4 - October 20, 2010

The fourth survey was conducted eight days after the third survey by one acoustic survey vessel with one fine scale systematic parallel transect surveys completed on a single school of herring (Figure 82; Table A25). This was the only aggregation of herring observed by the one survey vessel (*Bradley K*). Given the absence of observed fish no non-recording vessels accompanied the survey vessel and coverage of the total survey box was limited. The single school was only 0.77km^2. No multi-panel samples were collected from the aggregation and the last fishery sample occurred on October 6 (Figure 76). Biomass estimates were based on a standard 28cm herring with TS being adjusted for frequency. The spawning biomass for the single school observed during this survey was estimated to be 6,697t with the CIF and was used in the overall total for the area (tables 11, A25).

Halifax/Eastern Shore Acoustic Survey Summary for 2010

The 2010 acoustic surveys in the Halifax/Eastern Shore provided good coverage of the various herring spawning locations in the survey area. As usual, the surveys were supported by a multi-panel gillnet to collect representative samples of herring being surveyed on each of the survey nights to better estimate TS. Unfortunately, there was a general absence of herring especially during the latter part of the season (Table 11; Figure 73).

The total spawning biomass for the Eastern Shore area for 2010 was taken as the sum of the September 26, October 4-5 and October 20 surveys, where there was not an overlap in either the 10 day time window or location (Table 11). The total spawning biomass estimate was

27,654t with the CIF. This represents a decline of about 10,000t in spawning biomass (Table 11; Figure 83). It is also the lowest observed biomass since 2001 for this area.

The results are considered to provide a reasonable estimate of herring present at the time of surveying. A major concern or source of uncertainty is the assumption that the surveys are simply cumulative. If herring do not move 'on to' and 'off of' the spawning grounds in waves, the estimate of total SSB will be significantly biased upward due to double counting. Another major issue, which was addressed at the 2007 Herring Framework review, is the use of these estimates as absolute measures of biomass due to the many uncertainties, especially with TS.

Although no spawning surveys were conducted between Liverpool and Chebucto Head, commercial landings during the spawning season were reported from the area (Table 12). Further investigation of the area is required to determine if herring are spawning in the area or just in transit to other spawning grounds.

Glace Bay Fishery and Surveys

Glace Bay Fishery and Surveys Survey coverage for the Glace Bay area was poor in 2010 with two surveys attempted on September 15 and October 20. There was no spawning fishery in the area due to a lack of markets, fish, and the lack of fishing activity may have prevented the opportunity for other boats to participate in the searching and survey activities.

Glace Bay Acoustic Survey #1 – September 15, 2010

This survey was conducted by a single acoustic survey vessel Natasha Lee that searched the area for spawning fish. However, since no fish were observed in several hours of surveying the data were not analyzed (Table 13).

Glace Bay Acoustic Survey #2 - October 20, 2010.

This was the second and final survey conducted by a single acoustic survey vessel, *Natasha Lee*, which undertook a broad scale systematic parallel transect survey over a 24.4km^2 area, where herring were traditionally observed (Figure 85). The overall coverage and layout of the transects was good but, consistent with previous years, very few fish were observed. The biomass for the overall survey was estimated to be 8t as calculated with the CIF (Table 13).

Glace Bay Acoustic Survey Summary for 2010

Survey coverage for the Glace Bay area was poor in 2010 with only one true survey completed throughout the entire spawning season. Virtually no herring were observed in 2010 with a total biomass estimate of 8t. This represents the lowest observed biomass since 2006 when no surveys were conducted. In addition, no biological samples collected, and there was no fishery in the area for 2010. Improvements in the survey timing, location and amount of survey effort are required in the future for this area.

Overall Coastal Nova Scotia Spawning Component

Landings and spawning biomass have fluctuated annually in the Little Hope/Port Mouton area with SSB increasing from a low in 2008 to around average in 2010 (Figure 71). The Halifax/Eastern Shore area has also shown several ups and downs in SSB in recent years with the 2010 SSB among the lowest since 2001 (Figure 83). Landings depict a similar pattern, except they took a marked increase and peaked in 2009. Landings were slightly above the long term average in 2010 (Figure 83). For the Glace Bay area there have been essentially no landings since 2005, partly due to availability and partly due to markets. Annual surveys in the area could not find any significant aggregations of spawning herring since about the same time (Figure 86). Small catches (180t) are also being taken along the coast from Liverpool to Chebucto Head (Table 12; Figure 84).

OFFSHORE SCOTIAN SHELF COMPONENT

Fleet activity/catch in the spring/early summer fishery on the offshore banks of the Scotian Shelf has varied between 1,000t and 20,000t since 1996 with landings of 5,263t in 2005. Acoustic recorders were activated on a few occasions, but insufficient quantities of fish were observed to warrant analysis. Consequently, no acoustic biomass estimates were available from the Scotian Shelf. There continues to be a lack of herring research on the Scotian Shelf in the fall using a research vessel like the *CCGS Alfred Needler* to investigate possible spawning activity in the offshore areas.

This is the first year an industry survey has been conducted on the offshore Scotian Shelf area since 2001. Acoustic recorders were activated in 2006 on a few occasions, but insufficient quantities of fish were observed to warrant analysis or the information was of poor quality with excessive interference from other electronics. Acoustic records were also made by the *Julianne III*, a purse seine/midwater trawl vessel, during operations in the offshore in 2005-2006. A large aggregation was reported and recordings were made in an area east of Sable Island along the shelf edge during November and December 2006. The acoustic system, which is a Simrad 200kHz ES60, has yet to be calibrated, so the data have not been analyzed (Power et al. 2007).

In 2010, the industry acoustic survey was completed during the spring fishery on the Offshore Banks. On June 8, ten vessels completed a total of 20 transects in an area where the fishery had been taking place on 'The Patch' (Figure 87). An area of 417km^2 was covered in a single night and an initial biomass estimate of 3,579t was derived using standard TS (Table A26). Fishery samples are available from subsequent fishing and could be applied to produce the final estimate (figures 88, 89).

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Table 1. Summary of the number of surveys scheduled and number undertaken in 2010, as well as the number of fishing nights examined in the estimation of spawning stock biomass (SSB) for the 4VWX stock and coastal component complexes.

Spawning Ground	Surveys Scheduled	Surveys Completed	Fishing Nights
Offshore Banks	1	1	0
Scots Bay	4	6	3
German Bank	5	8	0
Spectacle Buoy	2	3	0
Trinity Ledge	2	2	0
Little Hope	3	5	0
Eastern Shore	3	4	0
Glace Bay	2	2	0
Total	22	31	3

Table 2. Summary of completed herring acoustic surveys undertaken in 2010 with interval (days) between surveys on the same grounds, number of boats with acoustic systems, and the number of mapping boats (without acoustic systems using deck sheets only).

No.	Survey Date	Location of survey	Interval (days)	Acoutic Boats	Mapping Boats	Total No. Boats
1	08-Jun-10	Offshore Banks - Pat	0	10		10
2	26-Jun-10	Scots Bay #1	0	3		3
3	10-Jul-10	Scots Bay #2	14	6		6
4	24-Jul-10	Scots Bay #3	14	8		8
5	07-Aug-10	Scots Bay #4	13	11		11
6	21-Aug-10	Scots Bay #5	14	5		5
7	05-Sep-10	Scots Bay #6	14	5		5
8	10-Jul-10	Scots Bay Fishing Ni	0	4		4
9	14-Jul-10	Scots Bay Fishing Ni	4	1		1
10	19-Jul-10	Scots Bay Fishing Ni	5	1		1
11	18-Aug-10	German Bank #1	0	8	1	9
12	31-Aug-10	German Bank #2	13	7	0	7
13	08-Sep-10	German Bank #3	8	9	0	9
14	15-Sep-10	German Bank #4	7	9	0	9
15	23-Sep-10	German Bank #5	8	7	0	7
16	05-Oct-10	German Bank #6	12	9	0	9
17	19-Oct-10	German Bank #7	14	7	0	7
18	26-Oct-10	German Bank #8	7	5	0	5
19	02-Jun-10	Spec Buoy #1	0	1	3	4
20	04-Jun-10	Spec Buoy #2	2	1		1
21	17-Jun-10	Spec Buoy #3	15	1		1
22	19-Aug-10	Trinity Ledge #1	0	1	2	3
23	29-Aug-10	Trinity Ledge #2	10	1		1
24	21-Sep-10	Little Hope #1	0	2	14	16
25	03-Oct-10	Little Hope #2	12	2	16	18
26	11-Oct-10	Little Hope #3	8	2	13	15
27	19-Oct-10	Little Hope #4	8	2	22	24
26	25-Oct-10	Little Hope #5	6	1	13	14
27	26-Sep-10	Eastern Shore #1	0	2	14	16
28	05-Oct-10	Eastern Shore #2	9	2	0	2
28	12-Oct-10	Eastern Shore #3	7	1	0	1
29	20-Oct-10	Eastern Shore #4	8	1	0	1
30	15-Sep-10	Glace Bay #1	0	1		1
31	20-Oct-10	Glace Bay #2	35	1		1
	Total number of survey boat nights			137	98	235

Table 3. Summary of fish sampled by survey date and location with target strength (TS) estimate from samples, and TS estimate for a 28cm herring using the length/weight equation.

Date of Survey	Location of survey	Interval (days)	Number of Length Samples	Number of Fish Measured	Number Len/Wt Fish	Mean Length (mm)	Mean Weight (gm)	Target Strength dB/kg	Wt 28 cm Fish (gm)	TS 28 cm Fish dB/kg
08-Jun-10	Offshore Banks - Patch	0	12	1350	100	280	180	TO DO	TO DO	TO DO
26-Jun-10	Scots Bay #1	0	0	0	0	280	180	-35.500	180	-35.500
10-Jul-10	Scots Bay #2	14	5	613	175	269	153	-35.160	176	-35.422
24-Jul-10	Scots Bay #3	14	7	809	110	262	142	-35.083	180	-35.515
07-Aug-10	Scots Bay #4	13	10	1469	143	257	133	-34.935	178	-35.458
21-Aug-10	Scots Bay #5	14	4	461	43	254	122	-34.687	169	-35.247
05-Sep-10	Scots Bay #6	14	2	245	65	258	132	-34.864	173	-35.332
18-Aug-10	German Bank #1	0	3	318	129	270	150	-35.048	170	-35.257
31-Aug-10	German Bank #2	13	5	680	156	272	144	-34.792	161	-35.015
08-Sep-10	German Bank #3	8	6	882	101	268	141	-34.846	164	-35.116
15-Sep-10	German Bank #4	7	14	1932	127	264	133	-34.707	162	-35.049
23-Sep-10	German Bank #5	8	14	2061	134	267	137	-34.734	161	-35.032
05-Oct-10	German Bank #6	12	10	1554	97	267	138	-34.753	161	-35.033
19-Oct-10	German Bank #7	14	5	750	97	267	138	-34.750	161	-35.033
26-Oct-10	German Bank #8	7	0	0	0	267	138	-34.750	161	-35.500
02-Jun-10	Spec Buoy #1	0	0	0	0	280	180	-35.500	180	-35.500
04-Jun-10	Spec Buoy #2	2	0	0	0	280	180	-35.500	180	-35.500
17-Jun-10	Spec Buoy #3	15	0	0	0	280	180	-35.500	180	-35.500
19-Aug-10	Trinity Ledge #1	0	0	0	0	280	180	-35.500	180	-35.500
29-Aug-10	Trinity Ledge #2	10	0	0	0	280	180	-35.500	180	-35.500
21-Sep-10	Little Hope #1	0	0	0	0	280	180	-35.500	180	-35.500
03-Oct-10	Little Hope #2	12	0	0	0	280	180	-35.500	180	-35.500
11-Oct-10	Little Hope #3	8	2	190	57	289	186	-35.379	169	-35.244
19-Oct-10	Little Hope #4	8	0	0	0	280	180	-35.500	180	-35.500
25-Oct-10	Little Hope #5	6	0	0	0	280	180	-35.500	180	-35.500
26-Sep-10	Eastern Shore #1	0	1	78	29	314	0	-35.793	177	-35.436
06-Oct-10	Eastern Shore #2	10	2	263	62	306	207	-35.328	159	-34.962
12-Oct-10	Eastern Shore #3	6	0	0	0	280	180	-35.500	180	-35.500
19-Oct-10	Eastern Shore #4	7	0	0	0	280	180	-35.500	180	-35.500
15-Sep-10	Glace Bay #1	0	0	0	0	280	180	-35.500	180	-35.500
20-Oct-10	Glace Bay #2	35	0	0	0	280	180	-35.500	180	-35.500

Note - shaded cells represent values used for 38kHz system when no sampling was available. Further adjustments also made for frequency of systems used.

Table 4. Summary of the 2010 Scots Bay spawning ground acoustic survey data and associated biomass estimates for the standard survey box area (inbox) and for outside the survey box (outbox). The shaded row represents survey data which were not included in the overall totals.

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Scots Bay (inbox)	26-Jun-10	-35.78	430	-51.65	0.026	11,136	7,741	70
	10-Jul-10	-35.35	530	-50.84	0.028	14,982	9,383	63
	24-Jul-10	-35.13	580	-53.94	0.013	7,639	2,519	33
	07-Aug-10	-35.06	625	-52.07	0.020	12,461	3,143	25
	21-Aug-10	-34.81	540	-54.03	0.012	6,454	3,851	60
	05-Sep-10	-34.89	560	-63.60	0.001	754	471	62
Scots Bay total for standard survey area (inbox)						42,290	10,923	26%
Scots Bay (outbox)	10-Jul-10	-35.29	170	-54.185	0.013	2,190	243	11
(FISHING NIGHT)	10-Jul-10	-35.84	0.54	-26.64	8.584	4,636	1,550	33
	24-Jul-10	-35.20	220	-56.07	0.008	1,800	430	24
	07-Aug-10	-35.11	200	-57.84	0.005	1,067	142	13
	21-Aug-10	-34.70	100	-52.78	0.016	1,557	1,449	93
	05-Sep-10	-34.89	100	-58.04	0.005	484	270	56
Scots Bay total for non-standard survey area (outbox)						11,734	2,200	19%
Scots Bay overall total all survey areas						54,023	11,143	21%

Note 1: 26-Jun-2010 survey not included in totals due to lack of sampling to show evidence of spawning fish.

Note 2: calculated with calibration integration factor which was first introduced in 2003

Note 3: added estimate from fishing night data for schools located outside of survey area on July 10

Table 5. Summary of the 2010 German Bank spawning ground acoustic survey results and SSB biomass estimates for the standard survey box area (inbox) and for outside the survey box (outbox). The shaded rows represent survey data which were not included in the overall totals.

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m²)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
German Bank	18-Aug-10	-35.14	646	-44.19	0.124	80,370	17,333	22
	31-Aug-10	-34.95	646	-45.48	0.088	57,159	17,360	30
(not included in total)	08-Sep-10	-34.94	646	-44.93	0.100	64,880	23,248	36
	15-Sep-10	-34.88	646	-45.00	0.097	62,867	25,355	40
(not included in total)	23-Sep-10	-34.77	425	-48.85	0.039	16,637	7,991	48
	05-Oct-10	-34.96	646	-48.85	0.041	26,346	14,668	56
	19-Oct-10	-34.83	646	-53.92	0.012	7,972	2,113	27
(not included in total)	26-Oct-10	-34.80	646	-57.08	0.006	3,820	1,435	38
German Bank inbox total (not including Sept.8,Sept.23,Oct.26)						234,713	38,266	16%
German Bank (outbox)	18-Aug-10	-35.11	25	-42.27	0.192	4,810	1,644	34
	31-Aug-10	-34.84	80	-52.38	0.018	1,411	80	6
(not included in total)	08-Sep-10	-34.93	160	-54.06	0.012	1,959	1,012	52
	15-Sep-10	-34.81	120	-51.87	0.020	2,363	2,177	92
(not included in total)	23-Sep-10		0			0		
	05-Oct-10	-34.86	230	-48.60	0.042	9,722	9,389	97
	19-Oct-10	-35.04	230	-59.91	0.003	749	214	29
(not included in total)	26-Oct-10		0			0		
German Bank outbox total (not including Sept.8,Sept.23,Oct.26)						19,055	1,644	9%
German Bank overall (not including Sept.8,Sept.23,Oct.26)						253,768	38,301	15%

Note 1: Sept. 8 & 23, Oct 26 surveys not included in totals due to lack of sampling or within 14 day timing window
Note 2: calculated with calibration integration factor which was first introduced in 2003

Table 6. Catch dates, catch (t) and acoustic survey biomass (t) for the Spectacle Buoy and Trinity Ledge herring fishery from 1998 to 2010. Survey biomass calculated with CIF.

Year	Spec. Buoy catches and surveys				Trinity Ledge catches and surveys			
	Start Day	End Day	Catch t	Survey SSB t*	Start Day	End Day	Catch t	Survey SSB t*
1998	10-May-98	30-Jun-98	484	n/s	24-Aug-98	21-Sep-98	1,668	n/s
1999	10-May-99	16-Jul-99	355	n/s	12-Aug-99	15-Sep-99	1,257	3,885
2000	11-Jun-00	14-Jun-00	80	n/s	30-Aug-00	12-Sep-00	734	621
2001	11-Jun-01	10-Jul-01	699	1,110	21-Aug-01	26-Sep-01	1,012	14,797
2002	15-May-02	01-Jul-02	137	n/s	02-Sep-02	30-Sep-02	256	8,096
2003	04-Jun-03	06-Jun-03	69	1,420	21-Aug-03	18-Sep-03	369	12,117
2004	17-Jun-04	15-Jul-04	5	n/s	02-Sep-04	15-Sep-04	225	12,022
2005	09-Jun-05	11-Jul-05	124	290	05-Sep-05	20-Sep-05	447	10,701
2006	03-Jun-06	22-Jun-06	2	n/s	23-Aug-06	21-Sep-06	717	16,076
2007	07-May-07	22-Jun-07	243	310	27-Aug-07	20-Sep-07	1,091	3,113
2008	29-May-08	19-Jun-08	6	0	21-Aug-08	25-Sep-08	7	516
2009	11-Jun-09	25-Jun-09	0.2	n/s	01-Sep-09	11-Sep-09	116	1,575
2010	02-Jun-10	19-Jun-10	-	1,859	11-Aug-10	24-Sep-10	202	2,405
Avg.			170	832			623	7,160

* Survey SSB calculated with Calibration Integration Factor after 2003 inclusive

Table 7. Biomass estimation for the 2010 Spectacle Buoy area acoustic surveys. Survey biomass was calculated with CIF.

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighte Sa (dB/m^2)	Density (kg/m^2)	Biom (t)	Standar Error (t)	SE %
Spec#1-June 2	2-Jun-10	280	-36.0	8.8	-43.5	0.176	1,548	855	55
Spec#2-June 4	4-Jun-10	280	-36.0	0.7	-38.1	0.611	421	126	30
Spec#3-June 17	17-Jun-10	280	-36.0	0.4	-37.1	0.778	311	240	77
Spectacle Buoy total for 2010							1,859	888	48

Note 1: Spec Buoy June 4 survey was not included because it was too close in time and space to previous survey.

Table 8. Biomass estimation for the 2010 Trinity Ledge acoustic surveys. Survey biomass was calculated with CIF.

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Trinity #1	19-Aug-10	280	-36.0	4.5	-41.5	0.282	1,271	474	37
Trinity #2	29-Aug-10	280	-36.0	0.7	-33.5	1.745	1,134	278	24
Trinity Ledge total for 2010							2,405	550	23

Table 9. Summary of the minimum observed spawning stock biomass for each of the surveyed spawning grounds in the Bay of Fundy/SWNS component of the 4WX stock complex. Total SSB rounded to nearest 100t and all data since 2001 calculated with the CIF. Data for 1997 to 2000 are calculated 'without' the CIF and are shown to complete the series of all surveys.

Location/Year	1999*	2000*	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average 2001-2010
Scots Bay (inbox)	41,000	106,300	216,000	129,700	123,000	115,000	21,200	31,600	50,500	23,300	81,600	42,300	83,420
Scots Bay (outbox)									2,200	100	6,100	11,700	5,025
Scots Bay total	41,000	106,300	216,000	129,700	123,000	115,000	21,200	31,600	52,700	23,400	87,700	54,000	85,430
German Bank (inbox)	460,800	356,400	257,300	416,200	348,800	392,000	268,600	290,500	495,400	238,600	395,900	234,700	333,800
German Bank (outbox)								4,900	4,000	2,400	1,700	19,100	6,420
German Bank total	460,800	356,400	257,300	416,200	348,800	392,000	268,600	295,400	499,400	241,000	397,600	253,800	337,010
Trinity Ledge	3,900	600	14,800	8,900	12,100	12,000	10,700	16,100	3,100	500	1,600	2,400	8,220
Spec Buoy (spring)	0	0	1,100		1,200	n/s	600	n/s	300	0		1,900	850
Spec Buoy (fall)			87,500					**30**					43,765
Stock Area Sub-Total	505,700	463,300	576,700	554,800	485,100	519,000	301,100	343,130	555,500	264,900	486,900	312,100	439,923
Seal Island			3,900	1,200	11,900			10,000					6,750
Browns Bank			50,400					7,700					29,050
Total All Areas	505,700	463,300	631,000	556,000	497,000	519,000	301,100	360,830	555,500	264,900	486,900	312,100	448,433
Long term Average since 2001			439,923	439,923	439,923	439,923	439,923	439,923	439,923	439,923	439,923	439,923	
Difference from Long Term Average			136,777	114,877	45,177	79,077	-138,823	-96,793	115,577	-175,023	46,977	-127,823	
% difference from Long Term Average			31%	26%	10%	18%	-32%	-22%	26%	-40%	11%	-29%	

*Biomass estimates for 1999 to 2000 estimates were calculated 'without' CIF.

Table 10. The 2010 herring acoustic surveys for Little Hope/Port Mouton with survey biomass and final total for the area (calculated with CIF).

Location/Date	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Little Hope #1 - Sept. 21	-35.96	11.0	-35.67	1.071	11,746	1,775	15
Little Hope #2 - Oct. 3	-35.96	8.1	-41.94	0.252	2,044	406	20
Little Hope #3 - Oct. 11	-35.83	14.7	-36.16	0.927	13,614	2,796	21
Little Hope #4 - Oct. 19	-35.96	6.6	-34.45	1.418	9,305	1,204	13
Little Hope #5 - Oct. 25	-35.96	1.5	-36.50	0.885	1,327	341	26
Initial All Surveys	-35.93	41.8	-36.35	0.910	38,036	3,563	9%
Final 2010 Surveys (see note)	-35.92	27.2	-35.99	0.983	**26,687**	3,329	12%

Notes: exclude Oct. 3 too close in time/space to Oct. 11 survey; exclude Oct. 19 too close to Oct. 11 survey.

Table 11. The 2010 Halifax/Eastern Shore herring acoustic survey results with survey biomass and final total for the area (calculated with CIF).

Location/Date	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Sept. 26 survey	-36.24	2.5	-29.08	5.208	13,021	2,406	18
Oct.4_MOH_School 1	-35.88	0.9	-34.23	1.463	1,376	488	35
Oct.5_BK_School 1	-35.76	0.8	-27.64	6.489	4,867	1,221	25
Oct.5_MOH_School 1	-35.88	0.2	-27.02	7.696	1,693	540	32
Oct. 12 survey (not included)	-35.96	0.8	-38.10	0.612	459	159	35
Oct. 20 survey	-35.96	0.8	-26.57	8.698	6,697	2,041	30
Initial All Surveys	-35.95	5.9	-29.19	4.741	28,113	3,464	12%
Final All Surveys (see notes)	-36.44	5.2	-28.67	5.339	**27,654**	3,461	13%

Note: Exclude Oct. 12 school which was too close in time to Oct. 19 survey in same area.

Table 12. The 2000-2010 Lunenburg Box area (Liverpool to Chebucto Head for statistical districts 22-26) catch and effort with start and end dates, total catch, number of sets, number of days with landings and number of active vessels with landings in these districts.

YEAR	MINDAY	MAXDAY	DAY_RANGE	CATCH	NOSETS	NO_DAYS	NO_VESSELS
2000	01-May-00	14-Oct-00	167	27	46	34	11
2001	18-May-01	13-Oct-01	149	21	54	37	10
2002	05-May-02	12-Oct-02	161	29	84	48	15
2003	07-Jun-03	21-Oct-03	137	48	44	33	12
2004	13-Jun-04	30-Nov-04	171	32	34	22	12
2005	30-Jun-05	31-Oct-05	124	140	58	20	11
2006	03-May-06	30-Nov-06	212	64	134	53	18
2007	23-Jun-07	26-Nov-07	157	21	72	42	13
2008	04-May-08	06-Nov-08	187	47	106	44	14
2009	23-May-09	30-Nov-09	192	182	121	40	15
2010	30-Apr-10	12-Oct-10	166	164	80	31	15
Average			166	70	76	37	13

* note - set data available from 2006 on; previously only catch by day

Table 13. The 2010 herring acoustic surveys for Glace Bay (using standard TS with CIF; no samples available).

Location	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Glace Bay #1	15-Sep-10			?			0		
Glace Bay #2	20-Oct-10	280	-36.0	24.4	-70.7	0.0003	8	6	80

Note - reported activity in Sept but very little data was recorded; 11km over 2.5 hrs

Table 14. Landings, acoustic survey SSB and exploitation estimates by spawning area for coastal Nova Scotia with five-year and overall averages.

a - Landings by spawning area for coastal Nova Scotia with 5 year and overall averages

Landings (t)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average Catch Last 5 yr.	Average Catch All Years
Little Hope/Port Mouton		490	1,170	2,919	2,043	2,904	3,982	4,526	1,267	2,239	3,133	1,506	1,108	3,731	3,106	2,517	2,437
Halifax/Eastern Shore	1,280	1,520	1,100	1,628	1,350	1,898	3,334	2,727	4,176	3,446	3,348	3,727	2,381	6,045	2,456	3,591	2,694
Glace Bay		170	1,730	1,040	834	1,204	3,058	1,905	1,481	626	85	7	12	4	11	24	869
Bras d'Or Lakes	170	160	120	31	56	0	1	4	0	0	0	0	0	0	0	0	36
Total	1,450	2,340	4,120	5,618	4,283	6,006	10,375	9,162	6,924	6,311	6,566	5,240	3,500	9,780	5,573	6,132	5,816

b - Acoustic SSB for coastal Nova Scotia with 5 year and overall averages (with CIF since 2003; w/o CIF pre-2003)

Survey SSB (t)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10% SSB Average Last 5 yr	10% SSB Average All years
Little Hope/Port Mouton			14,100	15,800	5,200	21,300	56,000	**53,100**	22,500	44,700	24,100	2,800	14,500	36,600	26,700	2,094	2,595
Halifax/Eastern Shore			8,300	20,200	**10,900**	16,700	**41,500**	92,600	28,400	36,950	68,900	28,300	30,300	54,200	27,700	4,188	3,577
Glace Bay				2,000		21,200	7,700	31,500		3,180	n/s	240	500	100	8	21	738
Bras d'Or Lakes				530	70	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	30

Note 1: shaded cells include mapping surveys which estimated biomass based on visual sounder estimates; bold cells include mapping and acoustic surveys.

c - Exploitation estimates for coastal Nova Scotia spawning components with 5 year and overa!! averages (with CIF since 2003; w/o CIF pre-2003)

Survey SSB (t) with CIF	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10% SSB Average Last 5 yr	10% SSB Average All years
Little Hope/Port Mouton			8%	18%	39%	14%	7%	**9%**	6%	5%	13%	54%	8%	10%	12%	19%	16%
Halifax/Eastern Shore			13%	8%	12%	11%	8%	3%	15%	9%	5%	13%	8%	11%	9%	9%	10%
Glace Bay				52%		6%	40%	6%		20%		3%	2%	4%	138%	37%	30%
Bras d'Or Lakes																	

Note 2: data prior to 2003 calculated with the Calibration Integration Factor (CIF) are not available and estimates of exploitation were not made for these years.

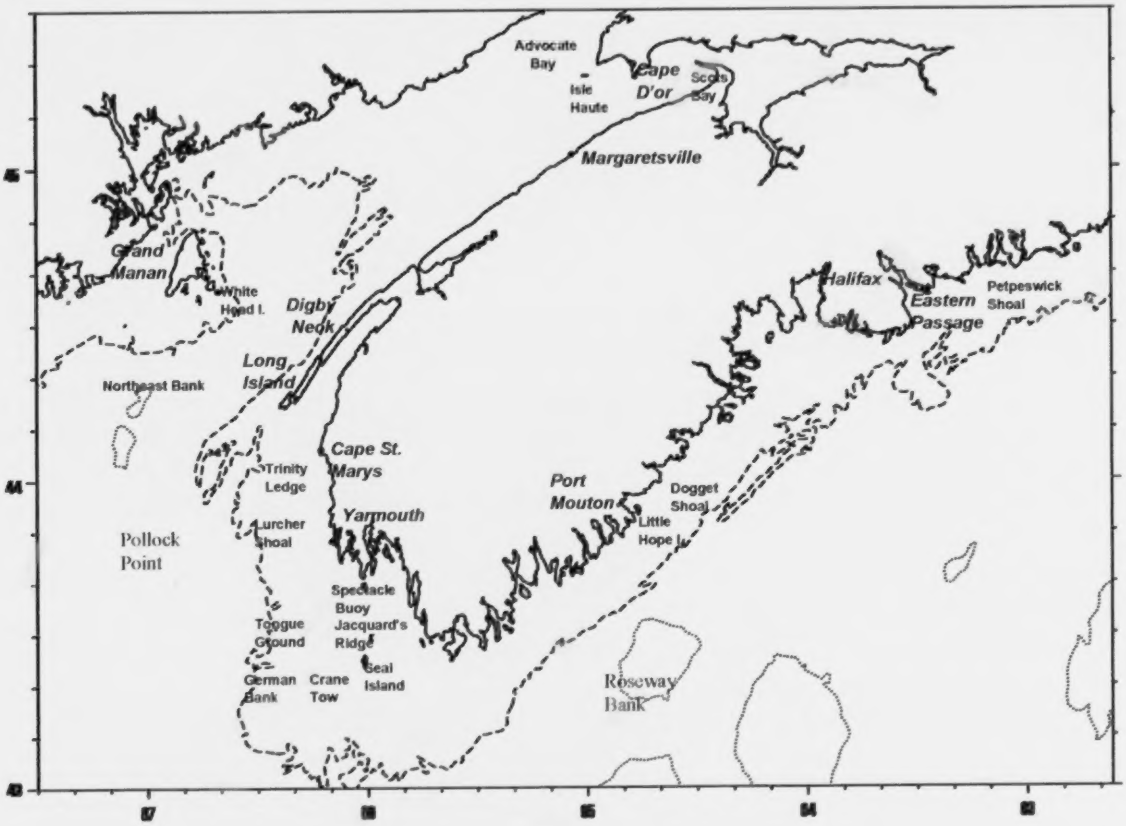

Advocate Bay
Isle Haute
Cape D'or
Scots Bay
Margaretsville
Grand Manan
White Head I.
Digby Neck
Long Island
Northeast Bank
Halifax
Eastern Passage
Petpeswick Shoal
Cape St. Marys
Trinity Ledge
Yarmouth
Port Mouton
Dogget Shoal
Little Hope I.
Lurcher Shoal
Pollock Point
Spectacle Buoy
Jacquard's Ridge
Seal Island
Trogue Ground
German Bank
Crane Tow
Roseway Bank
45
44
43
67
66
65
64
63

Figure 1. Map of the major spawning areas within the NAFO divisions 4WX herring stock complex.

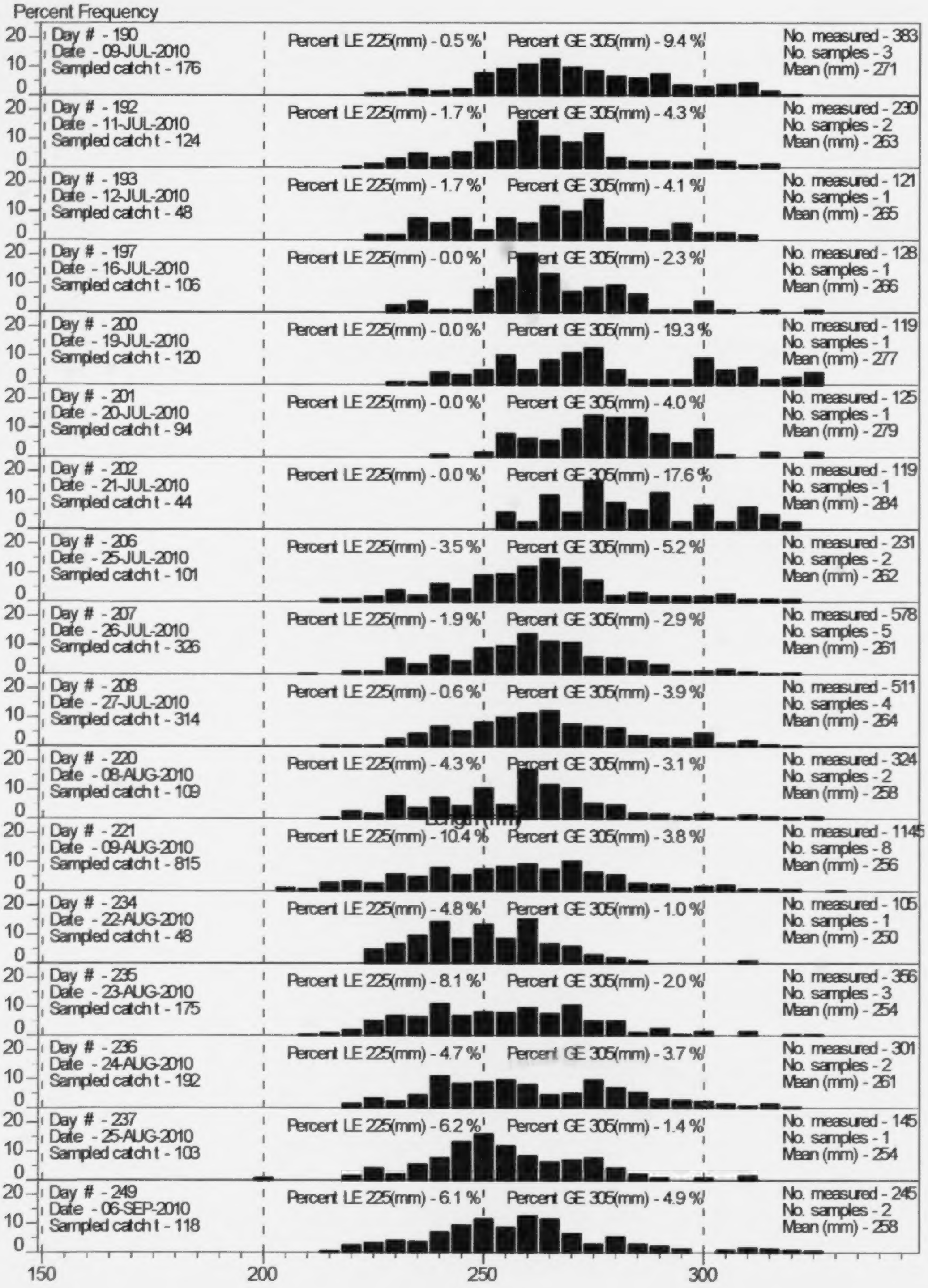


Figure 2. 2010 Scots Bay daily herring length frequency samples collected from all landings with proportions <=225mm and >=305mm. Length scale in millimeters with measurements grouped by ½cm.

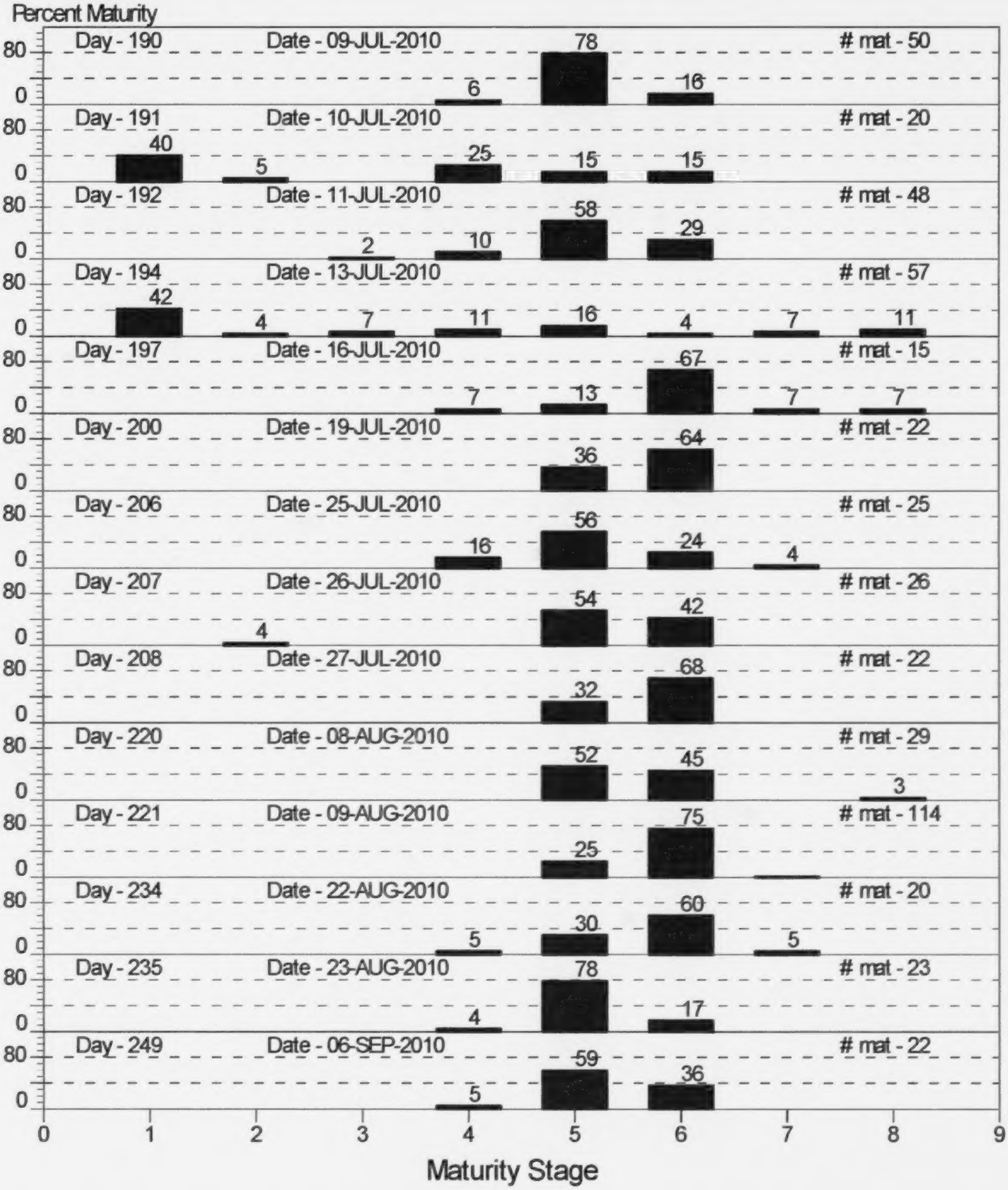


Figure 3. Daily herring maturity samples collected from Scots Bay landings in 2010. (Staging codes 1-2=immature; 3-4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering).

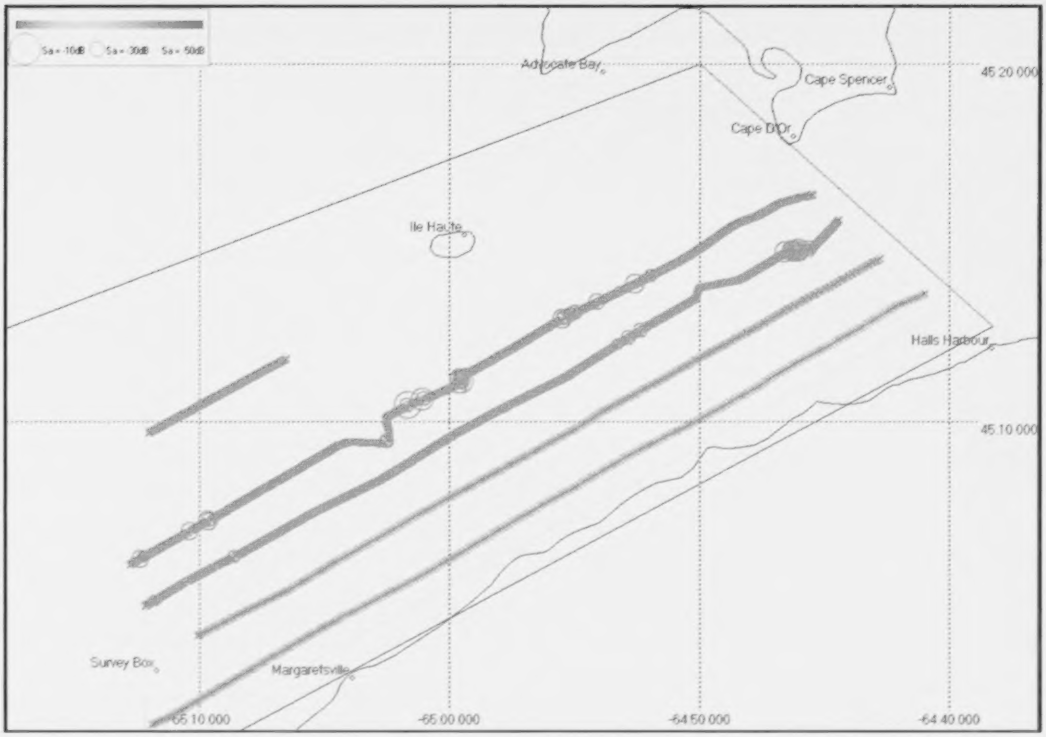

Sa = -10dB
Sa = 30dB
Sa = 50dB
Advocate Bay
Cape Spencer
Cape D'Or
Ile Haute
Halls Harbour
Survey Box
Margaretsville
45 20.000
45 10.000
-65 10.000
-65 00.000
-64 50.000
-64 40.000

Figure 4. Scots Bay acoustic survey (#1) on June 26, 2010, showing transects inside the standard survey area, as well as deviations from the main survey lines to document fish near the lines.

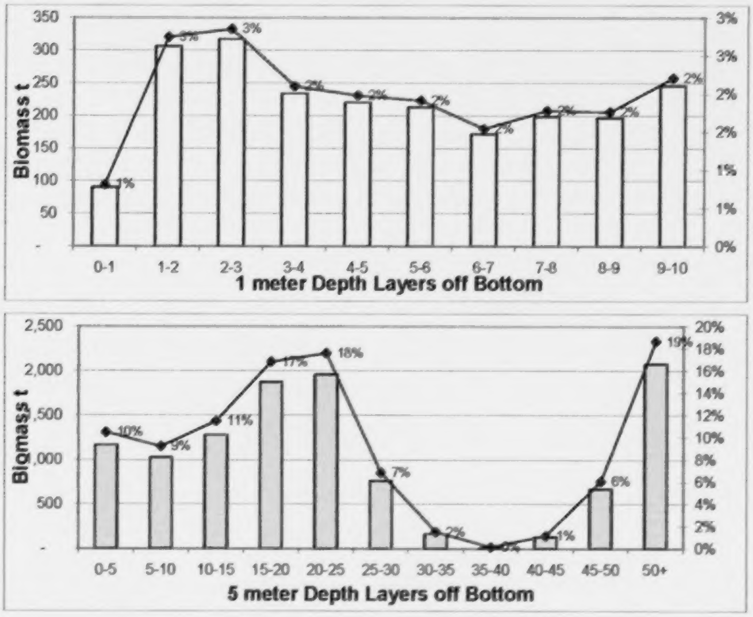


Figure 5a. Distribution of biomass by depth layer from bottom for the 2010 Scots Bay acoustic survey (#1) on June 26, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

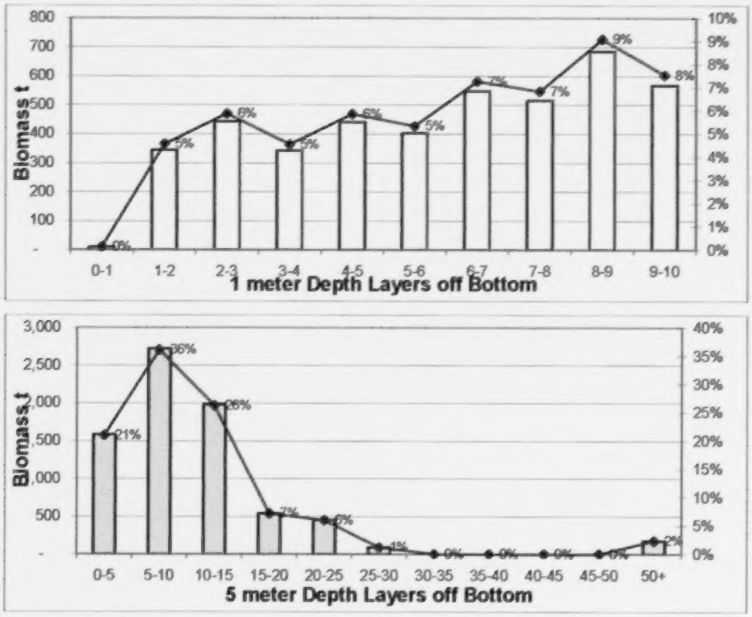


Figure 5b. Distribution of biomass by depth layer from bottom for the 2009 Scots Bay acoustic survey (#1) on June 27, 2009. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

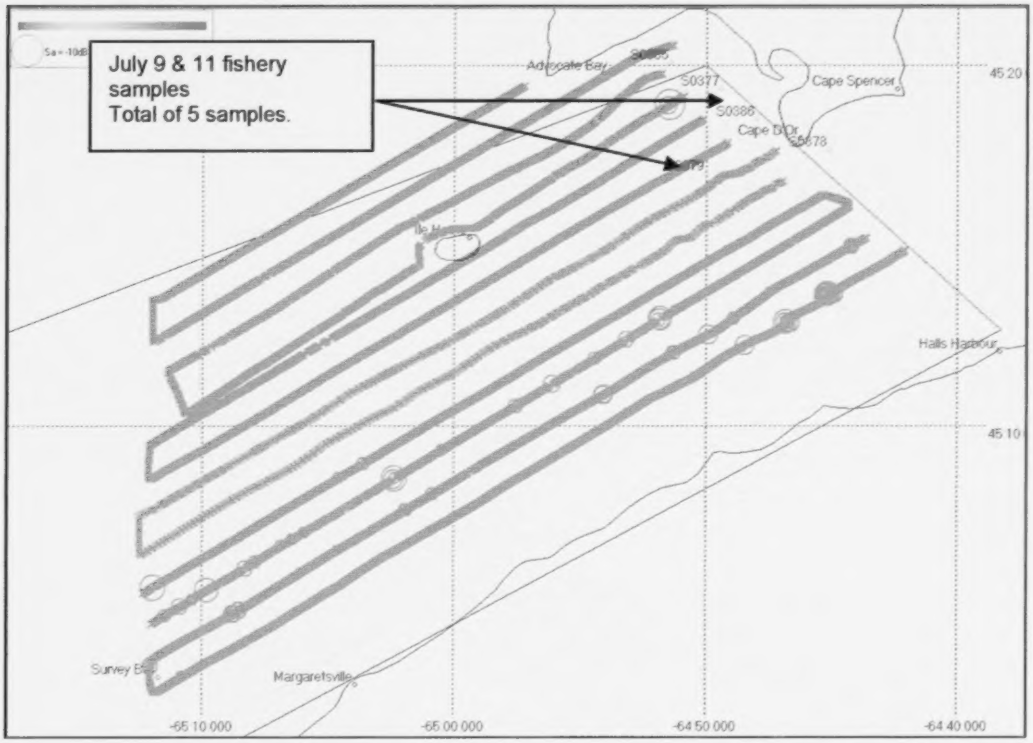

Sa = -10dB
July 9 & 11 fishery samples
Total of 5 samples.
Advocate Bay
S0377
S0386
Cape Spencer
Cape D'Or
Halls Harbour
Margaretsville
45 20
45 10
-65 10 000
-65 00 000
-64 50 000
-64 40 000

Figure 6. Scots Bay acoustic survey (#2) on July 10, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Locations for July 9 and 11 fishery samples are indicated by arrows for the general area with sample number shown.

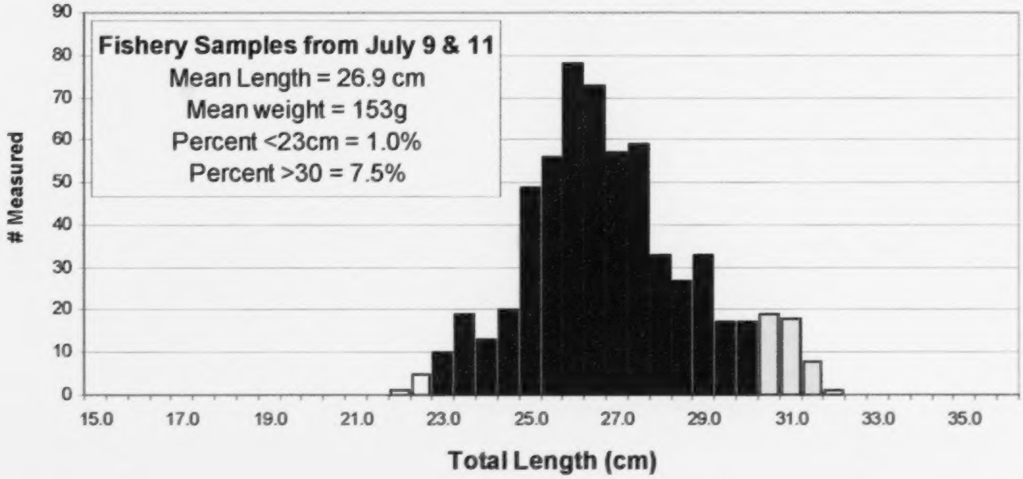


Figure 7. Length distribution used for calculation of TS for the Scots Bay acoustic survey (#2) on July 10, 2010, from sampling on July 9 and 11 with proportions <23cm and >30cm shown as white and grey bars.

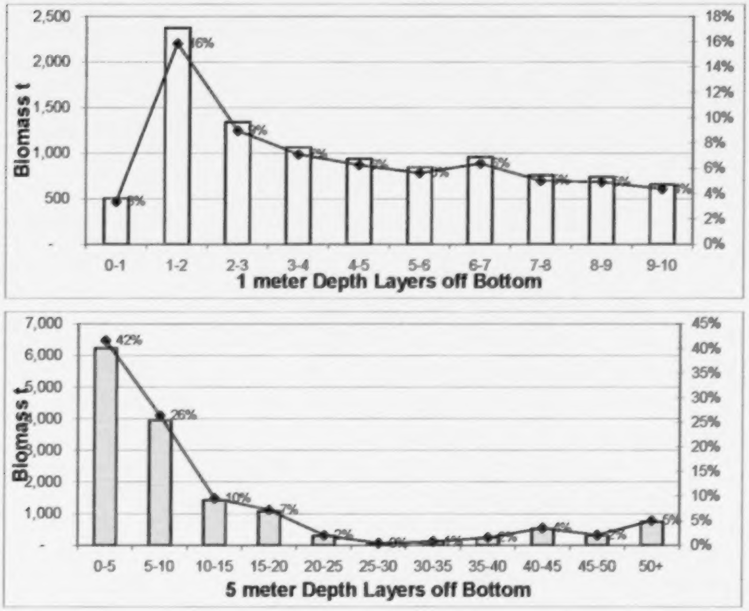


Figure 8. Distribution of biomass by depth layer from bottom for Scots Bay acoustic survey (#2) on July 10, 2010. Biomass is histogram bars and percent is a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

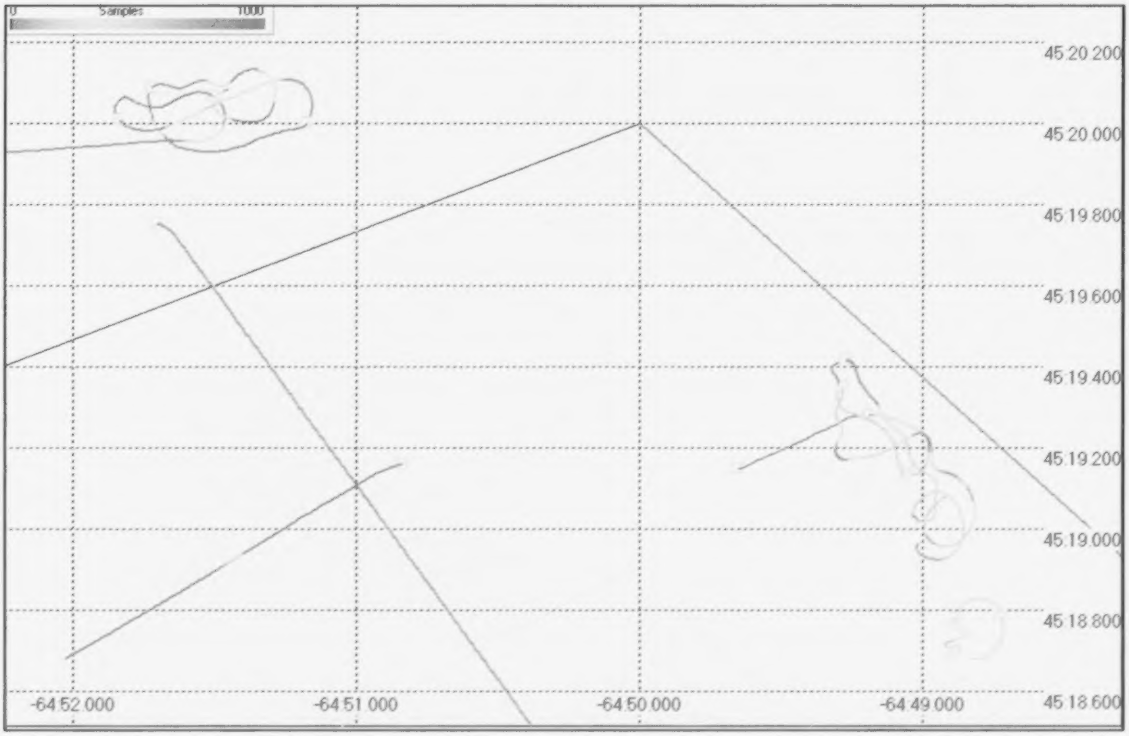

0
Samples
1000
45:20.200
45:20.000
45:19.800
45:19.600
45:19.400
45:19.200
45:19.000
45:18.800
45:18.600
-64:52.000
-64:51.000
-64:50.000
-64:49.000

Figure 9. Scots Bay fishing transects near Advocate Bay on July 10, 2010, showing the inner survey box and outer corner of the spawning box area.

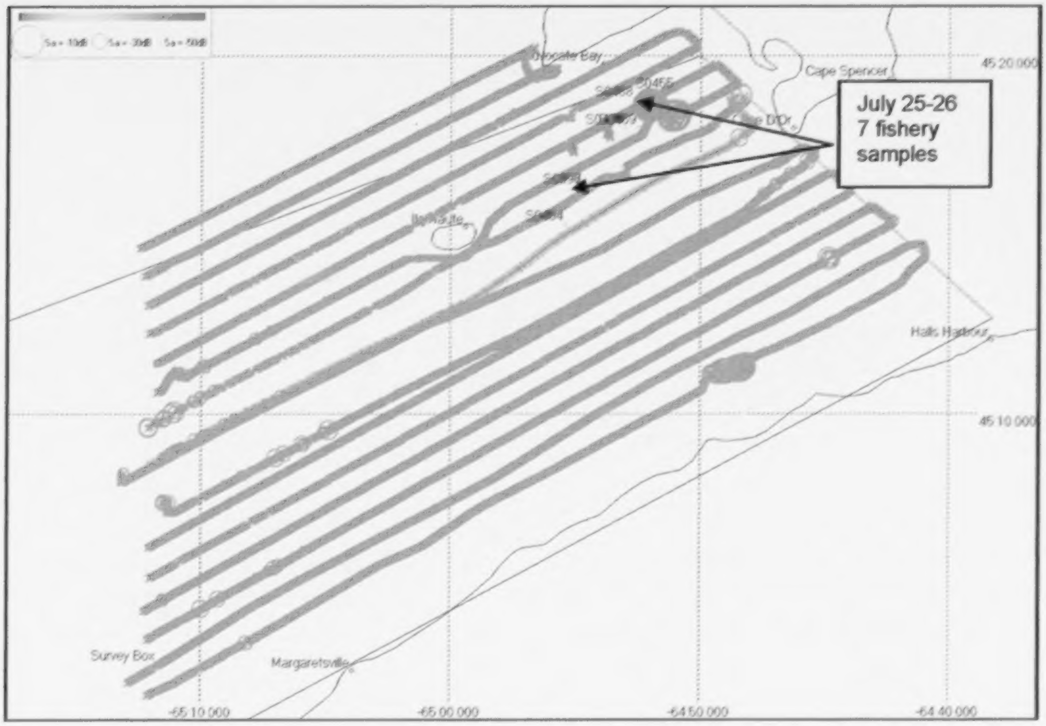

Sa = 10dB
Sa = 30dB
Sa = 50dB
Advocate Bay
Cape Spencer
S0455
Cape D'Or
Isle Haute
July 25-26
7 fishery samples
Halls Harbour
45 20.000
45 10.000
Survey Box
Margaretsville
-65 10.000
-65 00.000
-64 50.000
-64 40.000

Figure 10. Scots Bay acoustic survey on July 24, 2010, showing the main survey box (highlighted area) and transects completed with backscatter (Sa). Locations of fishery samples are indicated with identifier.

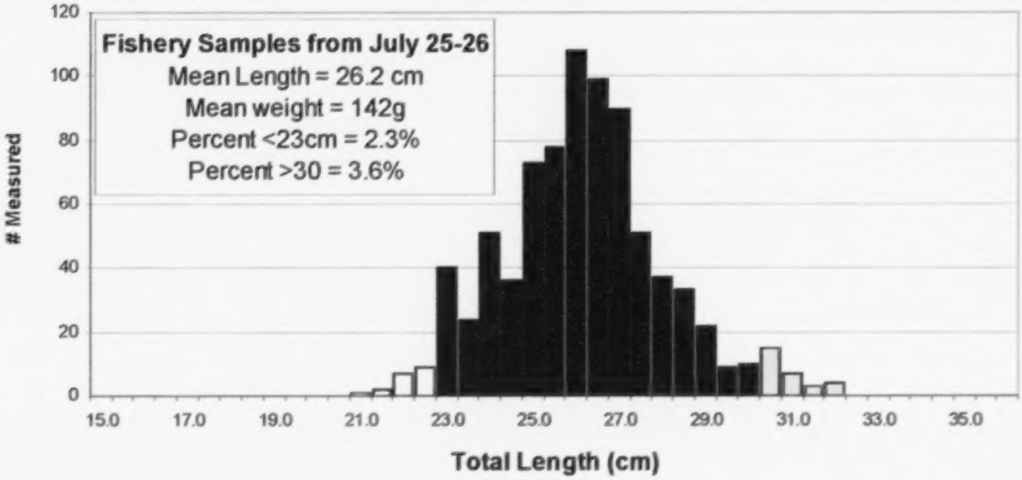


Figure 11. Length distribution used for calculation of TS for the Scots Bay acoustic survey (#3) on July 24, 2010, from sampling on July 25 and 26 with proportions <23cm and >30cm shown as white and grey bars.

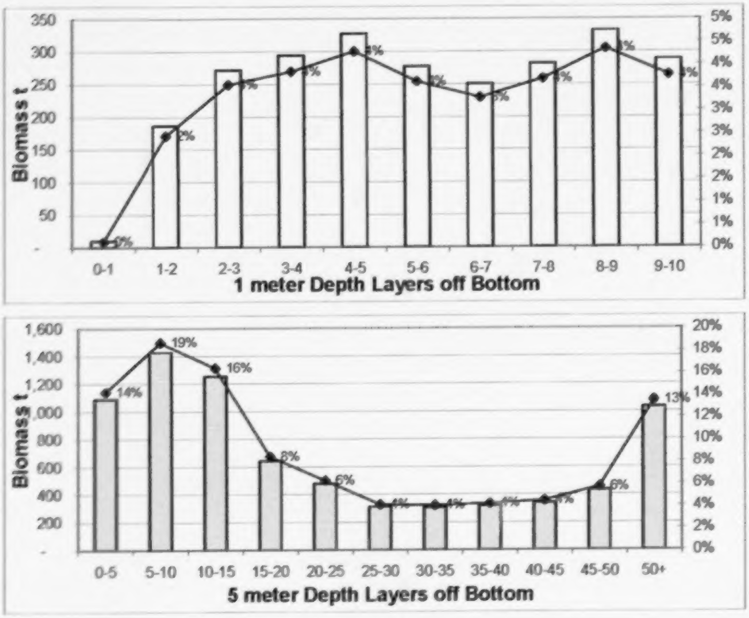
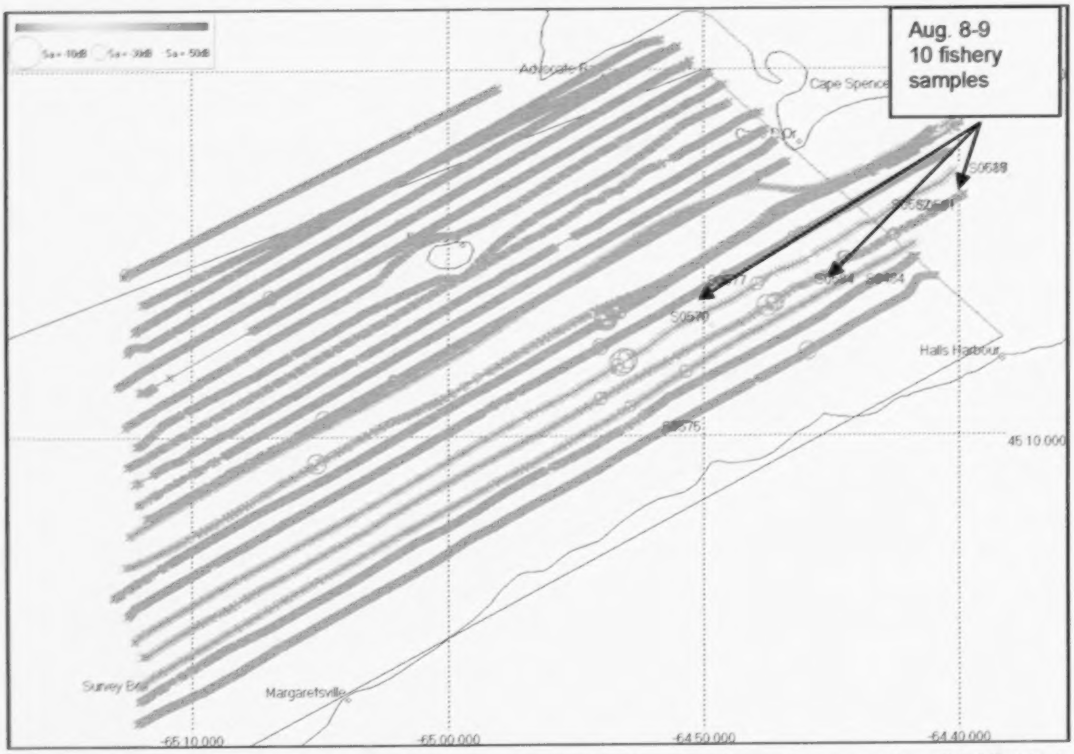


Figure 12. Distribution of biomass by depth layer from bottom for the Scots Bay acoustic survey (#3) on July 24, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).


Sa= 10dB
Sa= 30dB
Sa= 50dB
Advocate
Cape Spencer
S0688
S0570
Halls Harbour
45 10.000
Survey Box
Margaretsville
-65 10.000
-65 00.000
-64 50.000
-64 40.000

Aug. 8-9
10 fishery
samples

Figure 13. Scots Bay acoustic survey on August 7, 2010, showing the main survey box (highlighted area) and transects completed with backscatter (Sa). Locations of fishery samples are indicated with sample number.

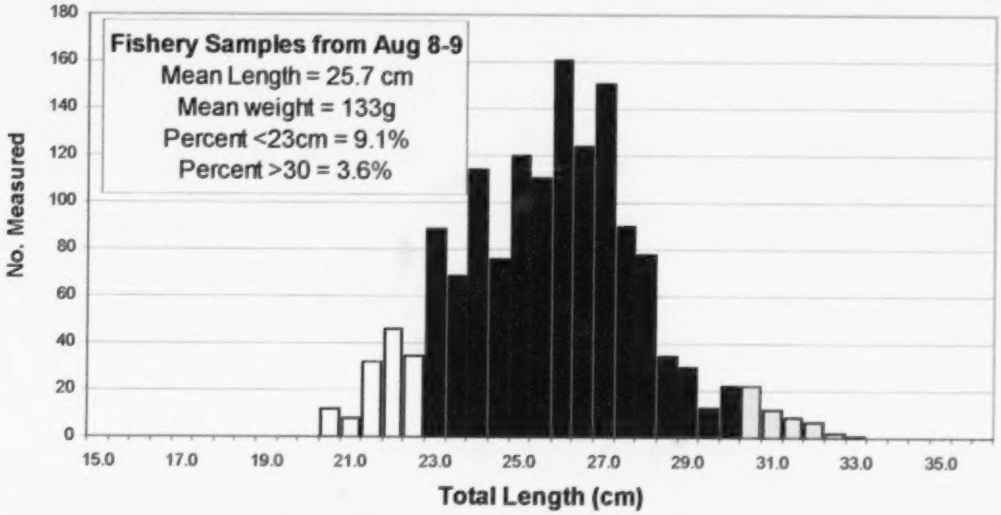


Figure 14. Length distribution used for calculation of TS for the Scots Bay acoustic survey (#4) on August 7, 2010, from sampling on August 8-9 with proportions <23cm and >30cm shown as white and grey bars.

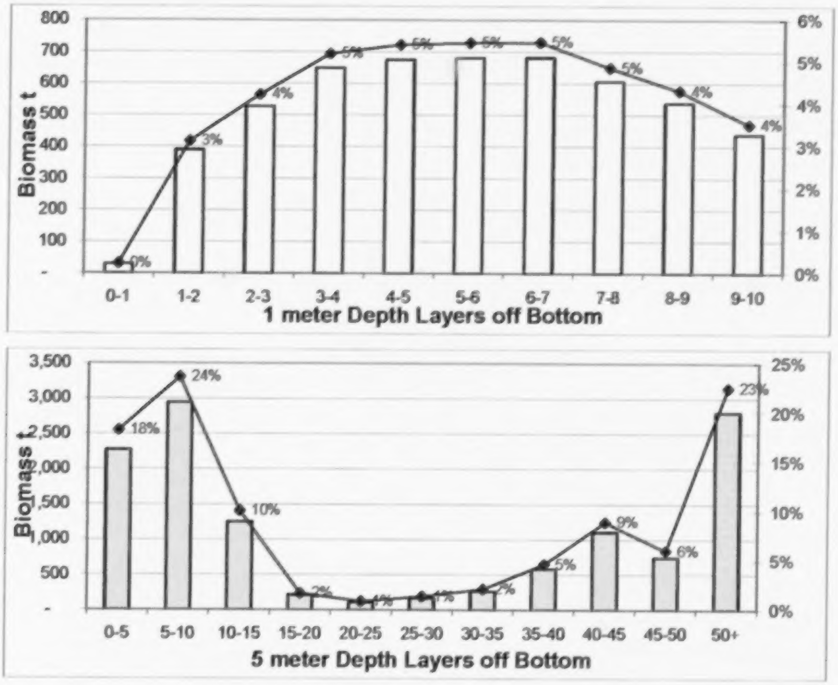


Figure 15. Distribution of biomass by depth layer from bottom for the Scots Bay acoustic survey (#4) on August 7, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

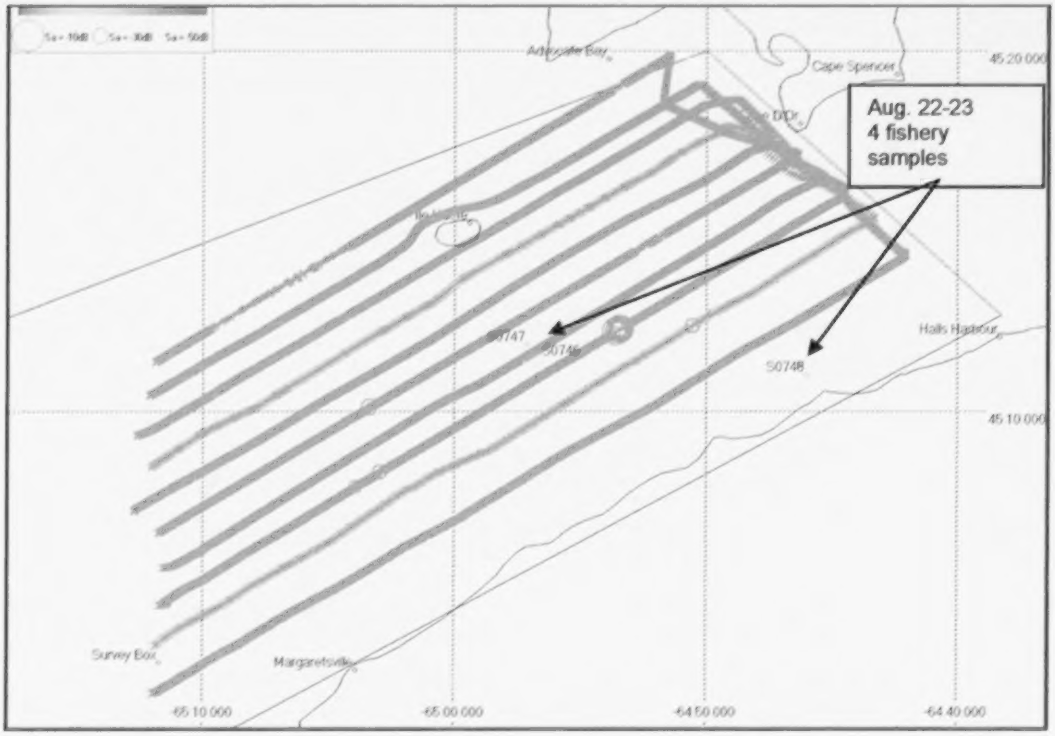

Sa = 10dB
Sa = 30dB
Sa = 50dB
Advocate Bay
Cape Spencer
Aug. 22-23
4 fishery samples
S0747
S0746
S0748
Halls Harbour
45 20 000
45 10 000
Survey Box
Margaretsville
-65 10 000
-65 00 000
-64 50 000
-64 40 000

Figure 16. Scots Bay acoustic survey on August 21, 2010, showing the main survey box (highlighted area) and transects completed with backscatter (Sa). Locations of fishery samples are indicated with sample number and a locator symbol.

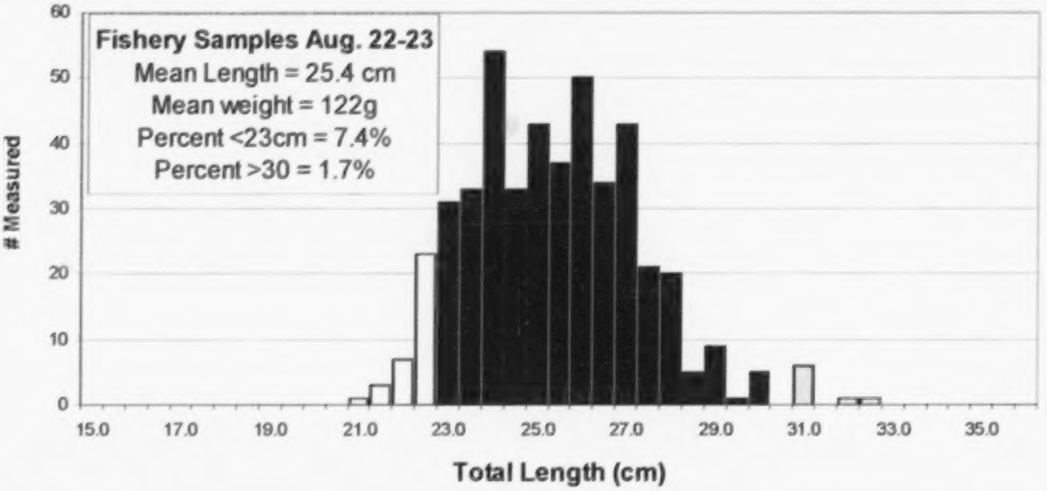


Figure 17. Length distribution used for calculation of TS for the Scots Bay acoustic survey (#5) on August 21, 2010, from sampling on August 22-23 with proportions <23cm and >30cm shown as white and grey bars.

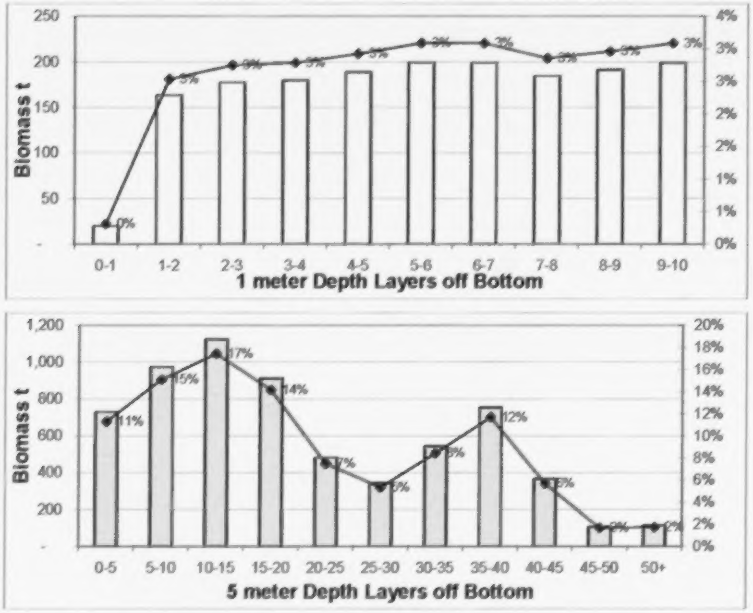
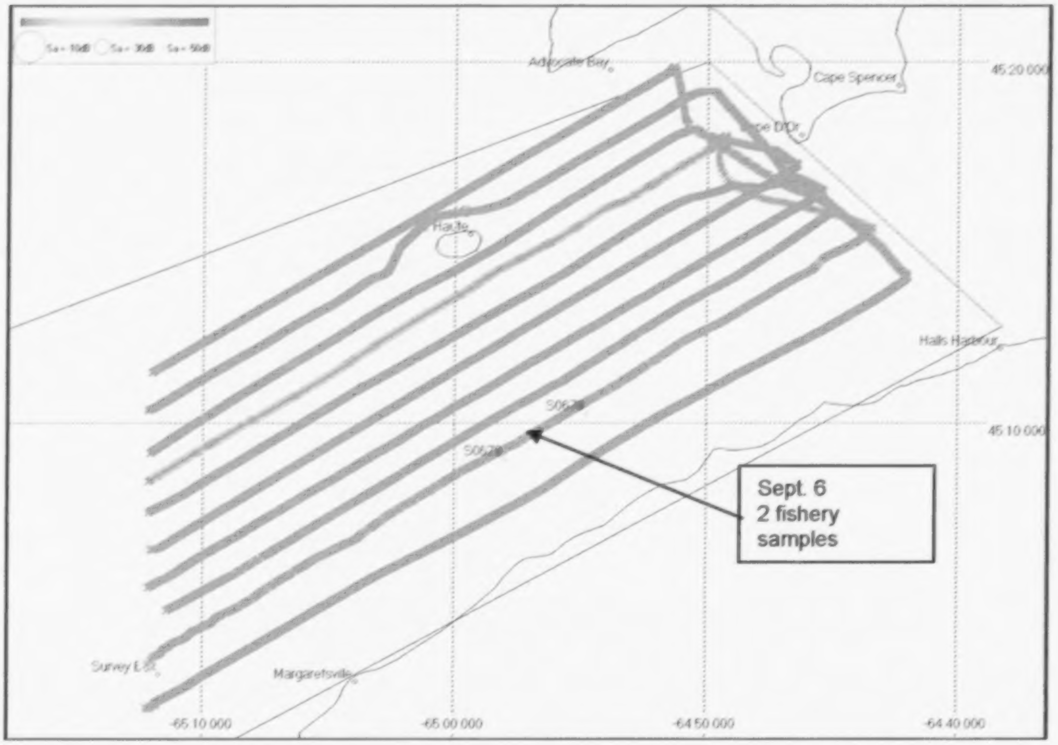


Figure 18. Distribution of biomass by depth layer from bottom for the Scots Bay acoustic survey (#5) on August 21, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).


Sa = 10dB
Sa = 30dB
Sa = 50dB
Advocate Bay
Cape Spencer
Cape D'Or
Haute
Halls Harbour
S0678
S0679
Survey Exit
Margaretsville
45 20 000
45 10 000
-65 10 000
-65 00 000
-64 50 000
-64 40 000

Sept. 6
2 fishery
samples

Figure 19. Scots Bay acoustic survey on September 5, 2010, showing the main survey box (highlighted area) and transects completed with backscatter (Sa). Locations of fishery samples are indicated by sample number and locator.

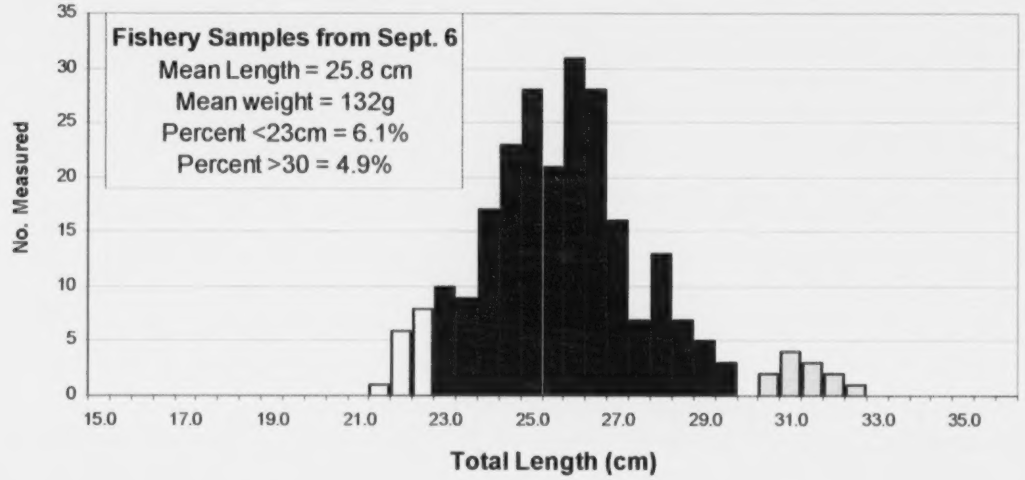


Figure 20. Length distribution used for calculation of TS for the Scots Bay acoustic survey (#6) on September 5, 2010, from sampling on September 6 with proportions <23cm and >30cm shown as white and grey bars.

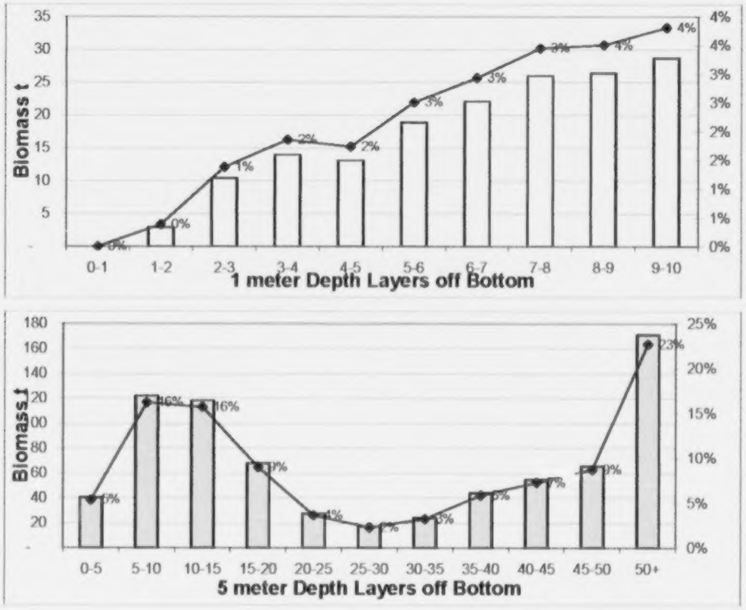


Figure 21. Distribution of biomass by depth layer from bottom for the Scots Bay acoustic survey (#6) on September 5, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

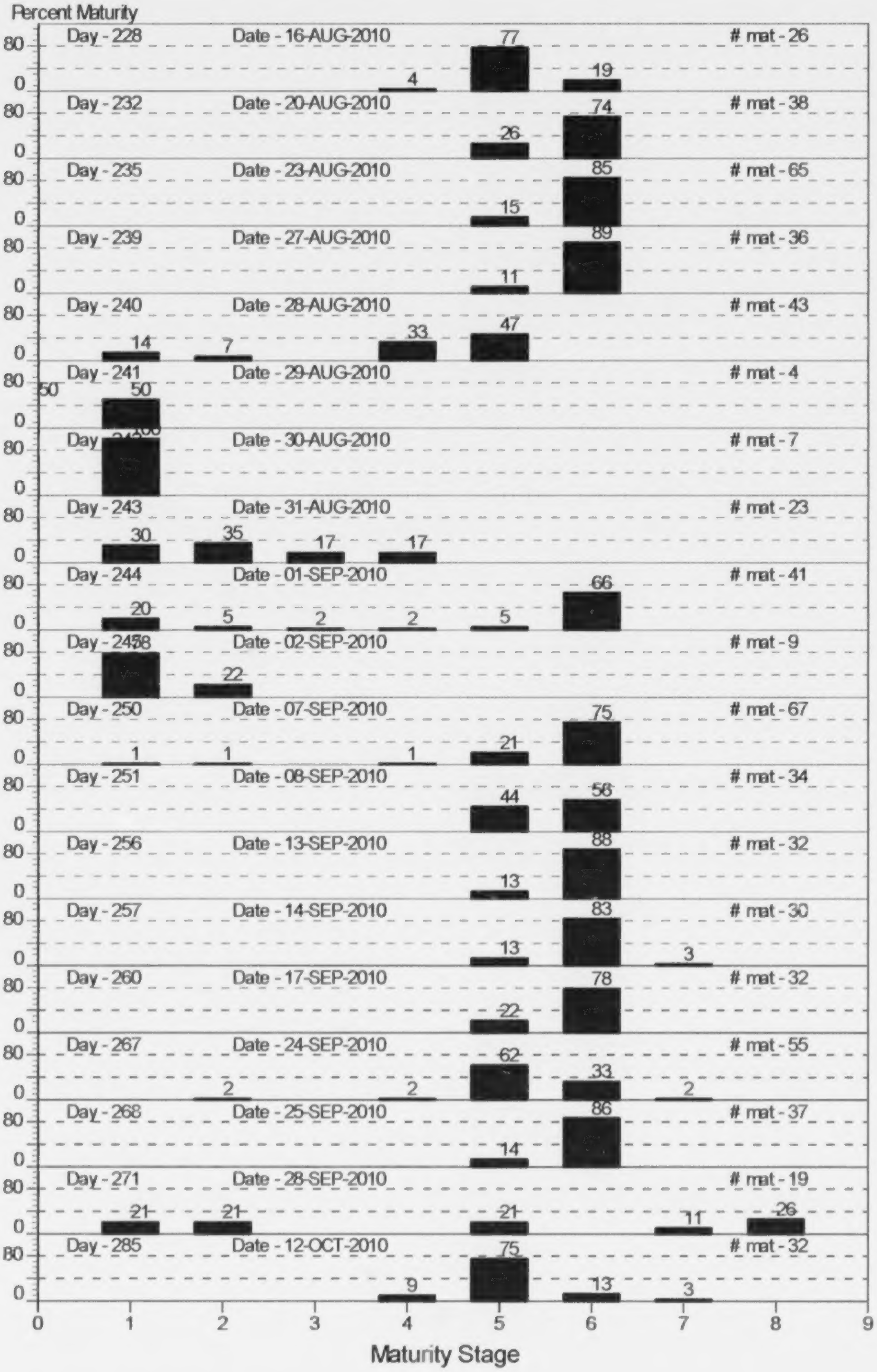


Figure 22. Daily herring maturity samples collected from German Bank survey box area in 2010. (Staging codes 1-2=immature; 3-4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering). Includes research midwater trawl samples collected by the Alfred Needler from August 28 to September 2.

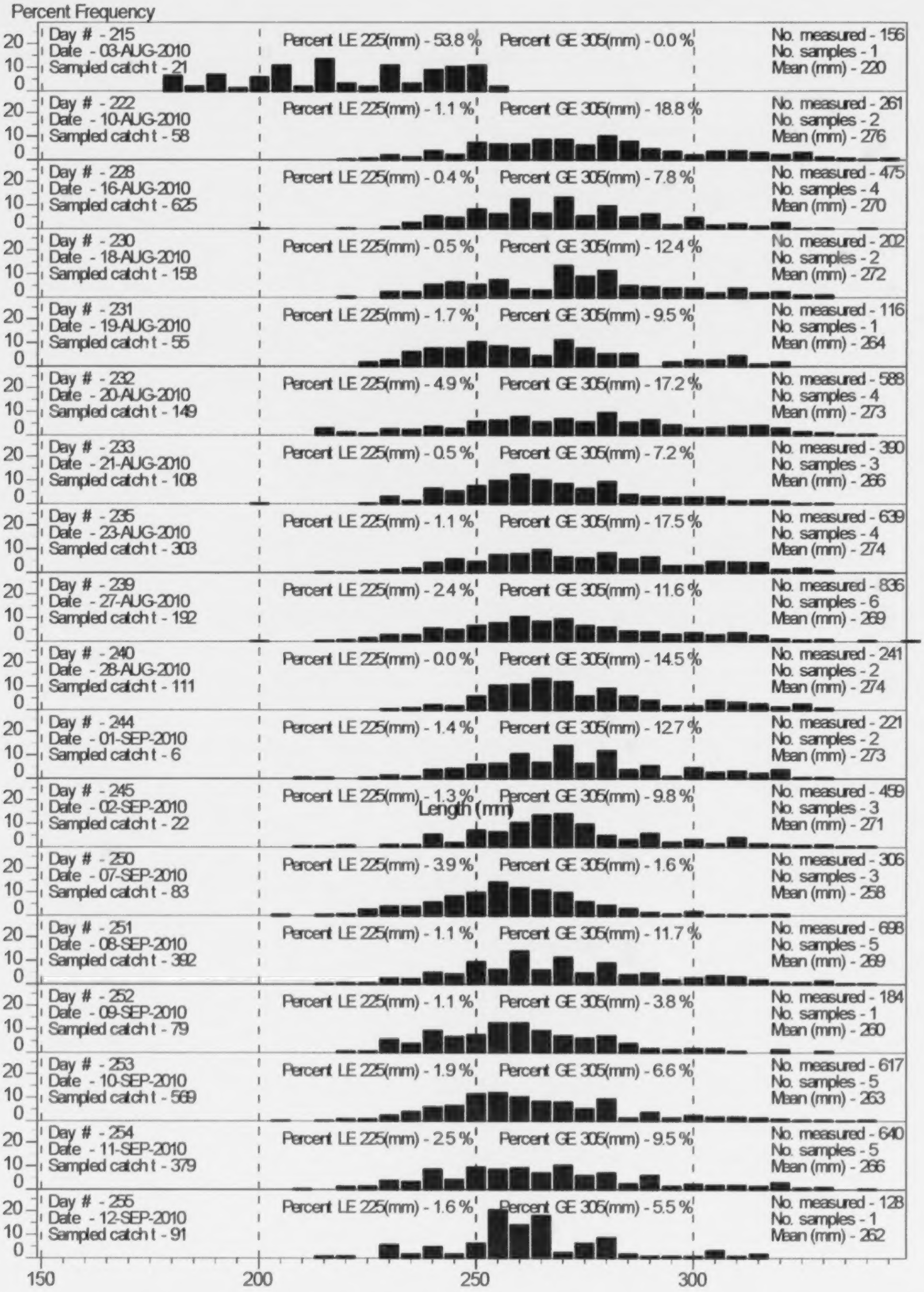


Figure 23a. Daily herring length frequency samples collected from 2010 German Bank survey box area for period from August 1 to September 12, 2010, with proportions <23cm and >30cm.

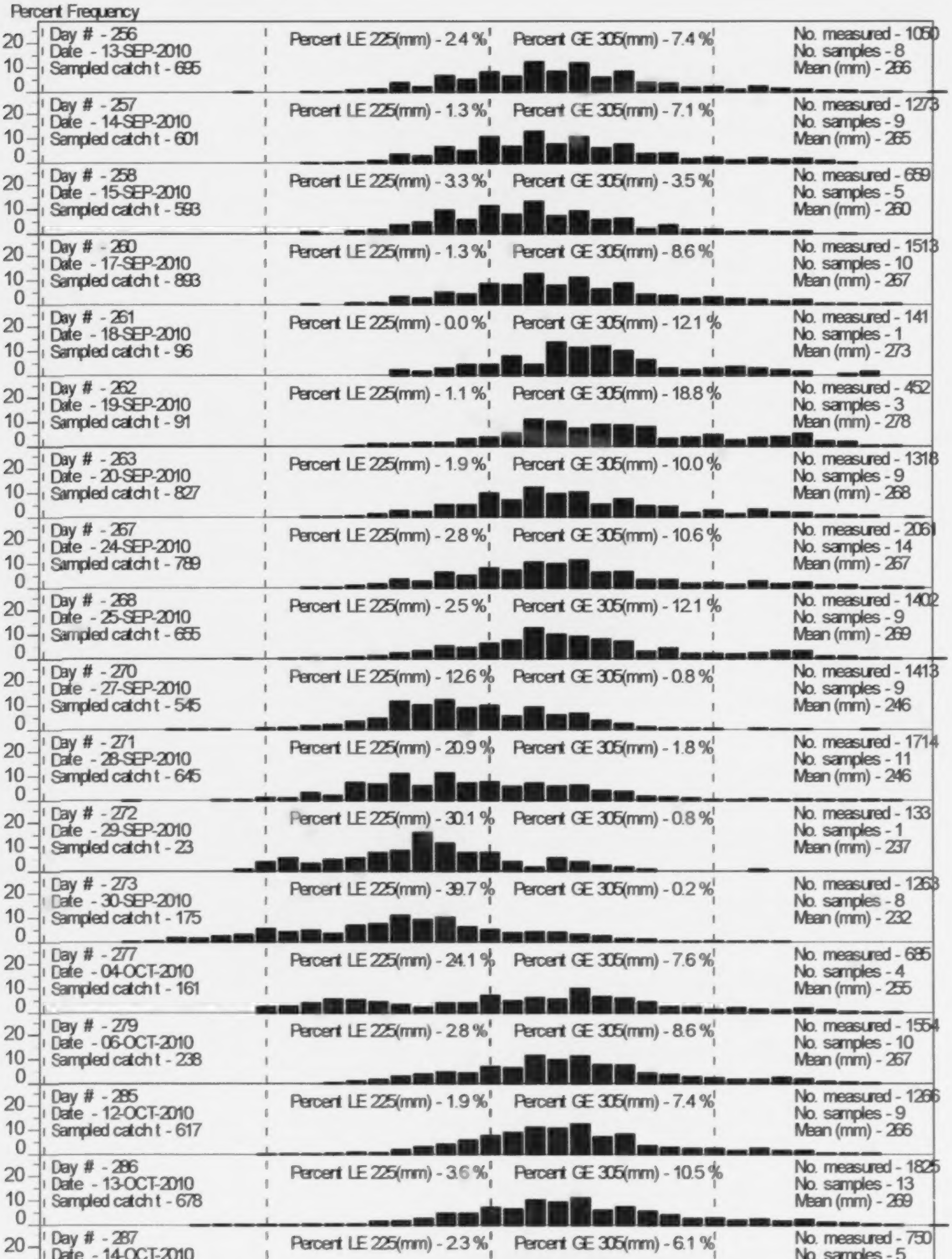


Figure 23b. Daily herring length frequency samples collected from 2010 German Bank survey box area for period from September 13 to October 14, 2010, with proportions <23cm and >30cm.

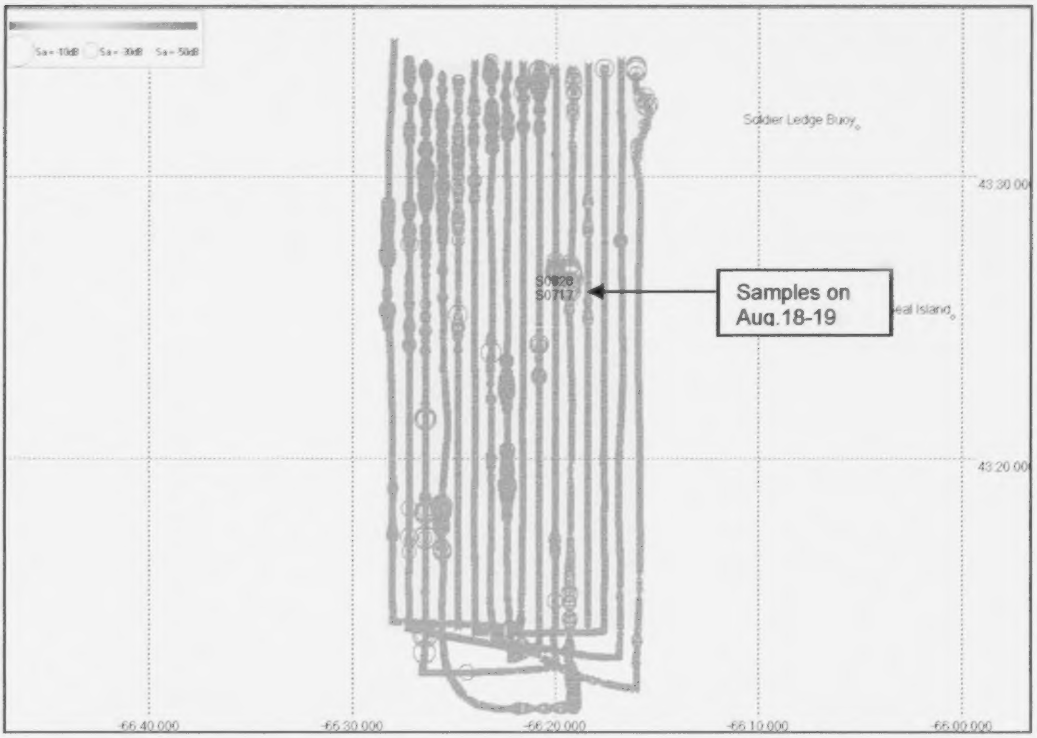

Sa = -10dB
Sa = -30dB
Sa = -50dB
Soldier Ledge Buoy
43 30.00
S0828
S0717
Samples on Aug.18-19
eal Island
43 20.00
-66 40.000
-65 30.000
-66 20.000
-66 10.000
-66 00.000

Figure 24. German Bank acoustic survey (#1) on August 18, 2010, with transects showing location and backscatter (Sa) in the main survey box (highlighted area). Survey lines were separated for inbox and outbox areas with the southern outbox area estimated as 25km^2. Locations of samples used in calculation of TS are indicated with arrow and sample number.

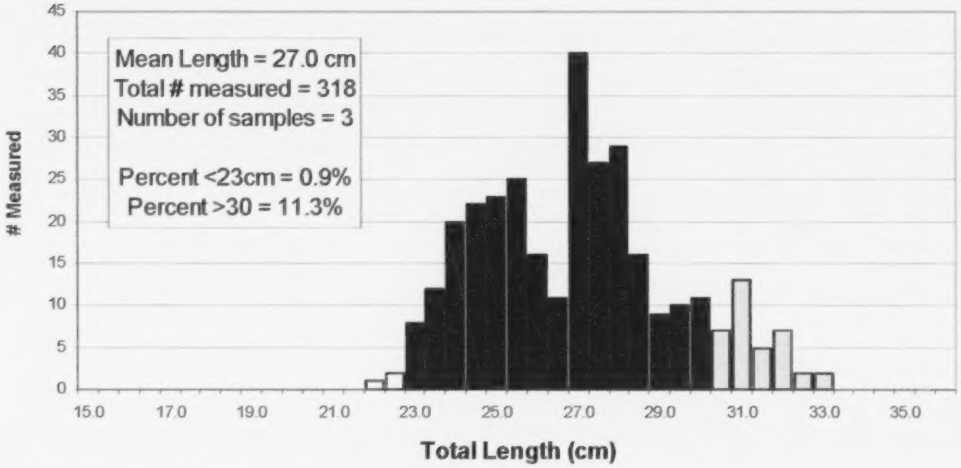


Figure 25. Length distribution used for calculation of TS for the German Bank acoustic survey (#1) on August 18, 2010, from sampling on August 18 to 19 with proportions <23cm and >30cm shown as white and grey bars.

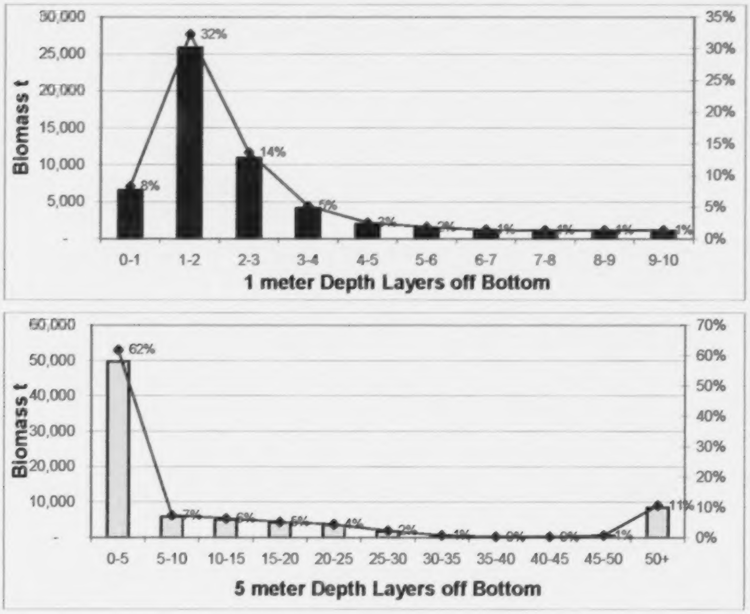
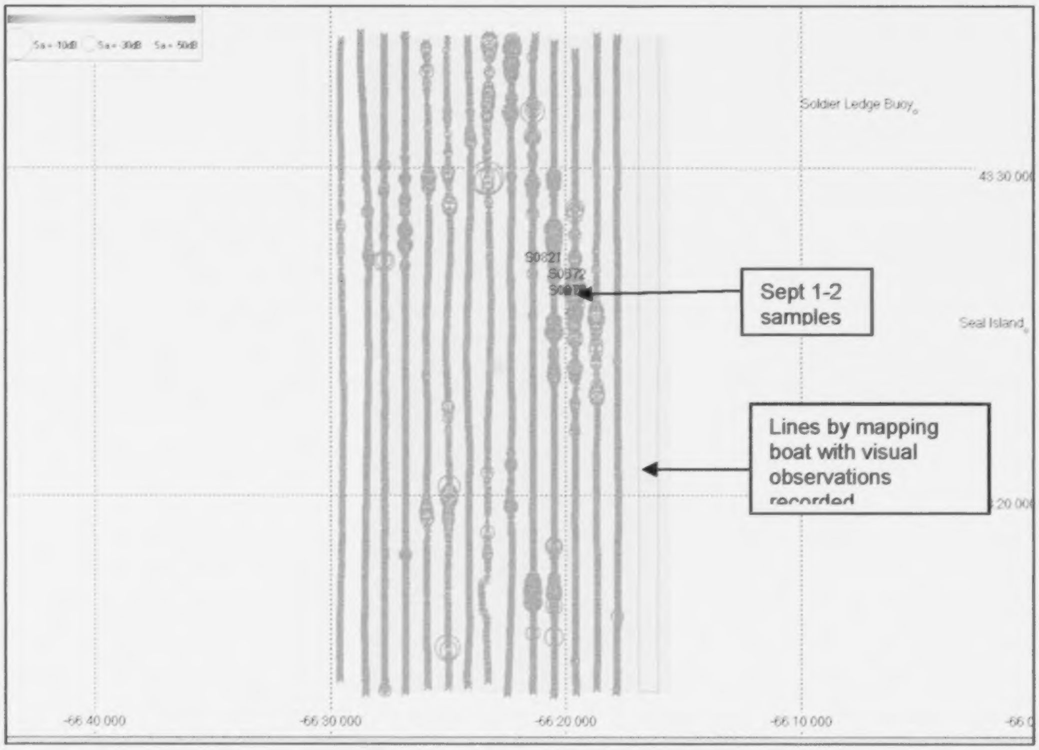


Figure 26. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey on August 18, 2010. Biomass and % of total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).


Sa = 10dB
Sa = 30dB
Sa = 50dB
Soldier Ledge Buoy
43 30.00
Seal Island
S0821
S0872
20.00
-66 40.000
-66 30.000
-66 20.000
-66 10.000
-66

Sept 1-2 samples

Lines by mapping boat with visual observations recorded

Figure 27. German Bank acoustic survey (#2) on August 31, 2010, with transects showing location and backscatter (Sa) in the main survey box (highlighted area). Fishery samples are identified by location with sample number.

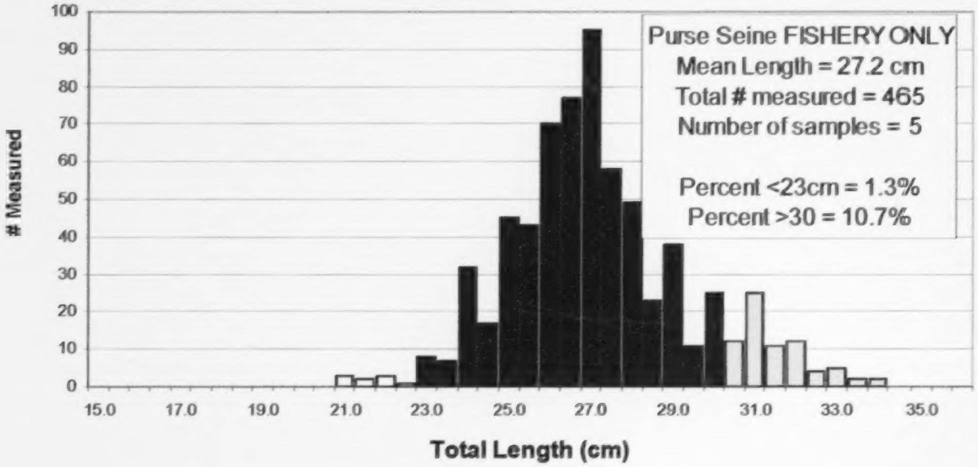


Figure 28. Length distribution used for final calculation of TS for the German Bank acoustic survey (#2) on August 31 based on September 1-2 sampling from purse seine fishery landings. Note proportions <23cm and >30cm shown as white and grey bars.

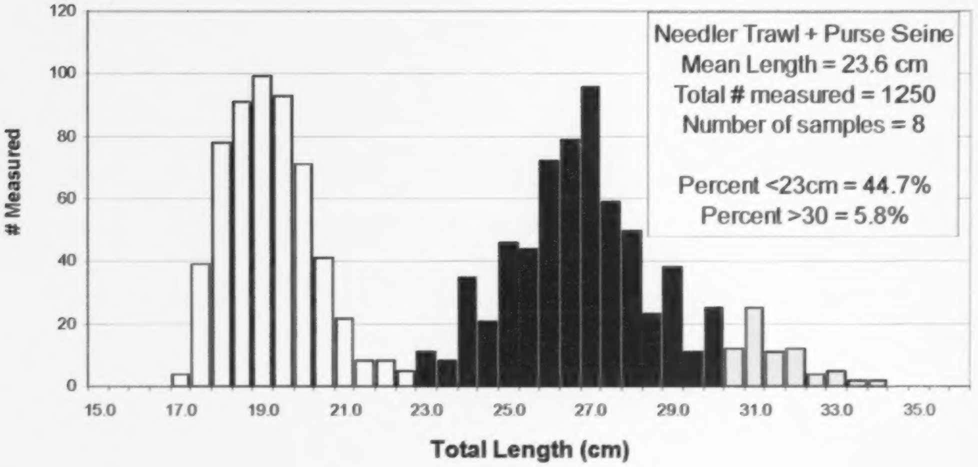


Figure 29. Length distribution for the German Bank area based on sampling from research midwater trawl and purse seine fishery landings on August 31 and September 1-2. Note proportions <23cm and >30cm shown as white and grey bars.

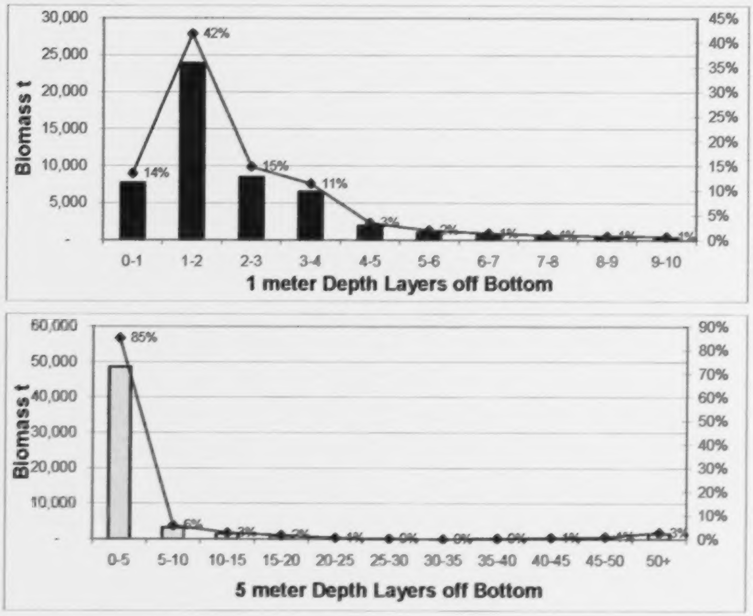
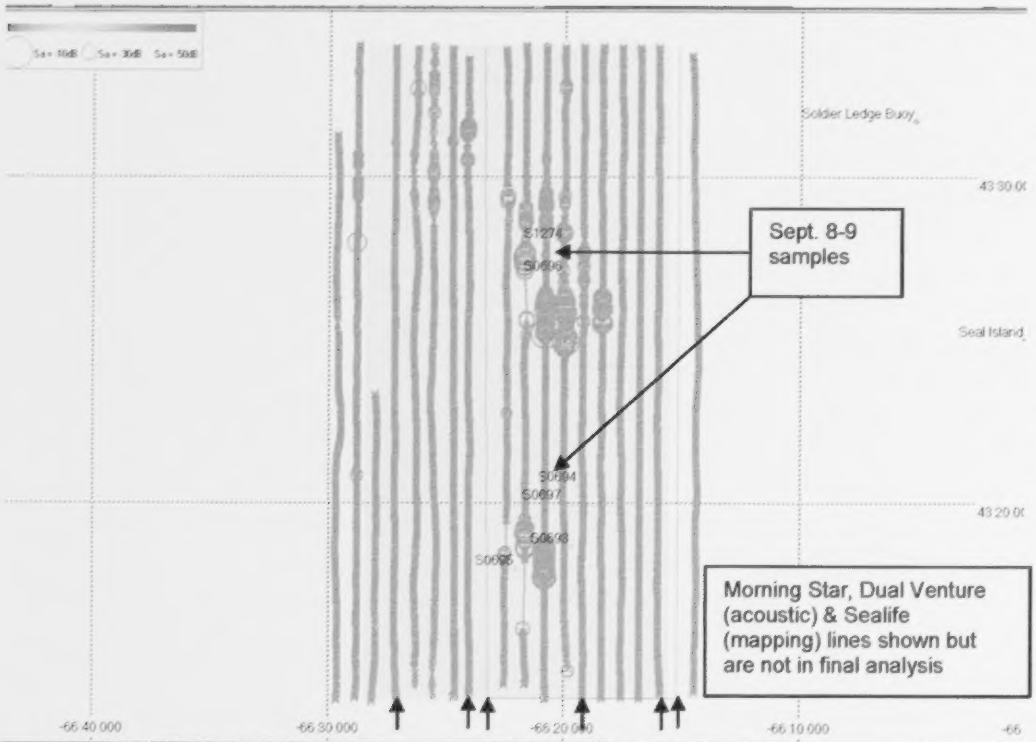


Figure 30. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey on August 31, 2010. Biomass and % of total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).


Sa = 10dB
Sa = 30dB
Sa = 50dB
Soldier Ledge Buoy
43 30.00
Seal Island
43 20.00
S1274
S0696
S0694
S0697
S0698
S0695
-66 40.000
-66 30.000
-66 20.000
-66 10.000
-66

Sept. 8-9 samples

Morning Star, Dual Venture (acoustic) & Sealife (mapping) lines shown but are not in final analysis

Figure 31. German Bank acoustic survey (#3) on September 8, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Sample locations are indicated by arrows and sample number. The Morning Star, Dual Venture and Sealife lines are shown but were not included in the final analysis.

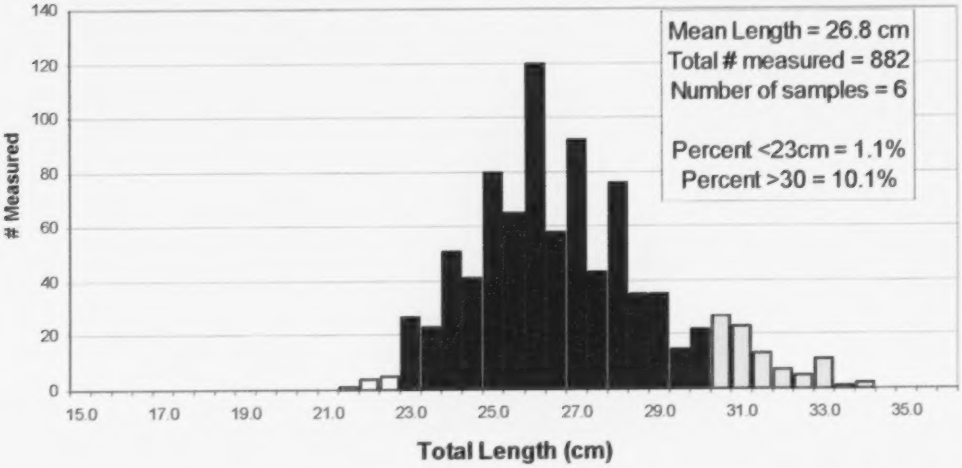


Figure 32. Length distribution used for calculation of TS for the German Bank acoustic survey (#3) on September 8, 2010, from sampling on September 8 to 9 with proportions <23cm and >30cm shown as white and grey bars.

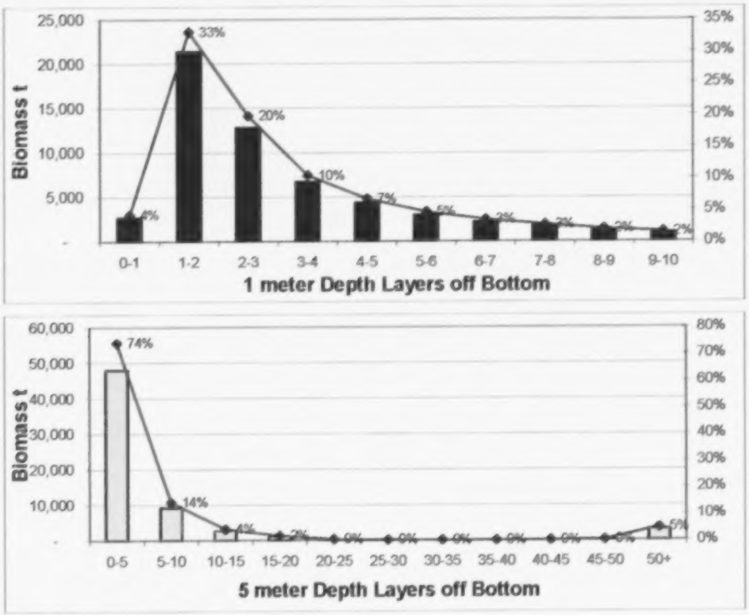


Figure 33. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey (#3) on September 8, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

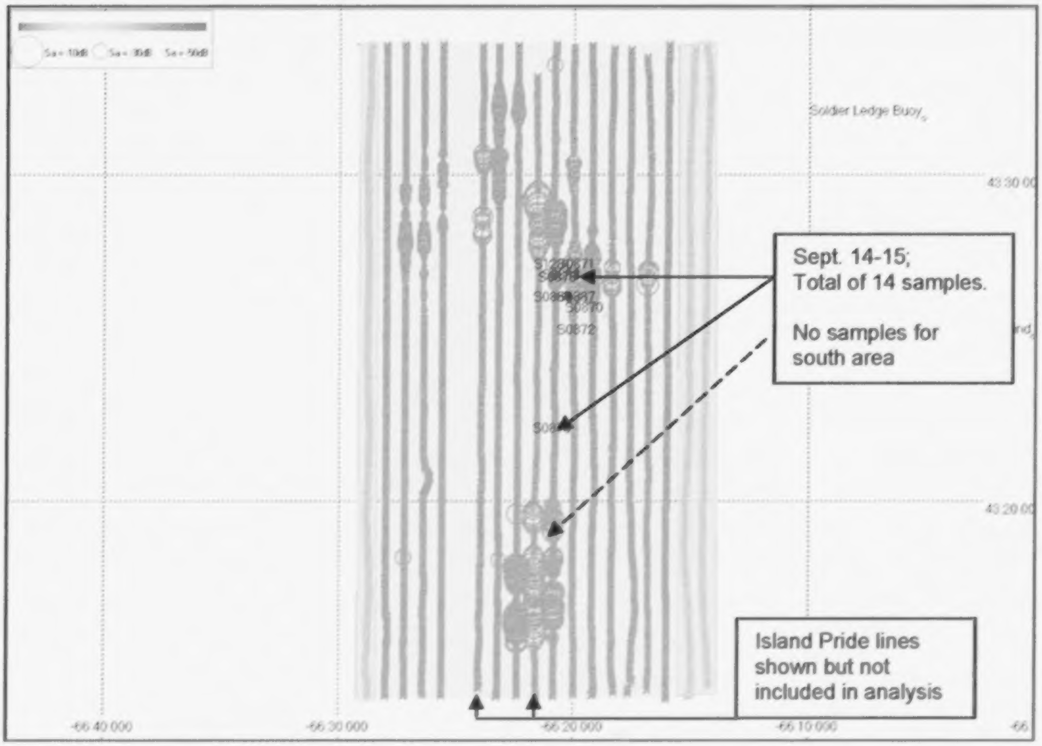

Sa = 10dB
Sa = 30dB
Sa = 50dB
Soldier Ledge Buoy
43 30 00
43 20 00
S0872
S0870
Sept. 14-15;
Total of 14 samples.
No samples for south area
Island Pride lines shown but not included in analysis
-66 40 000
-66 30 000
-66 20 000
-66 10 000

Figure 34. German Bank acoustic survey (#4) on September 15, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Sample locations are indicated by arrows and sample number.

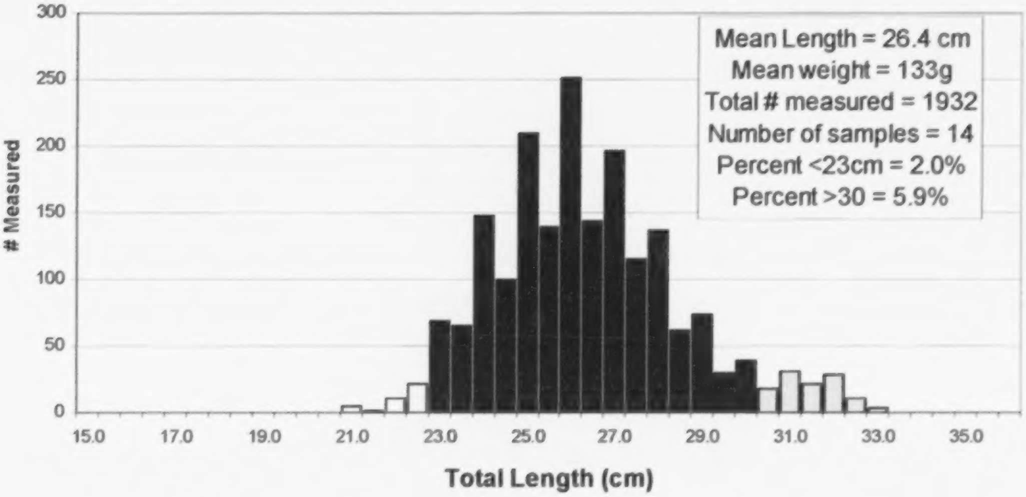


Figure 35 Length distribution used for calculation of TS for the German Bank acoustic survey (#4) on September 15, 2010, from sampling on September 14 to 15 with proportions <23cm and >30cm shown as white and grey bars.

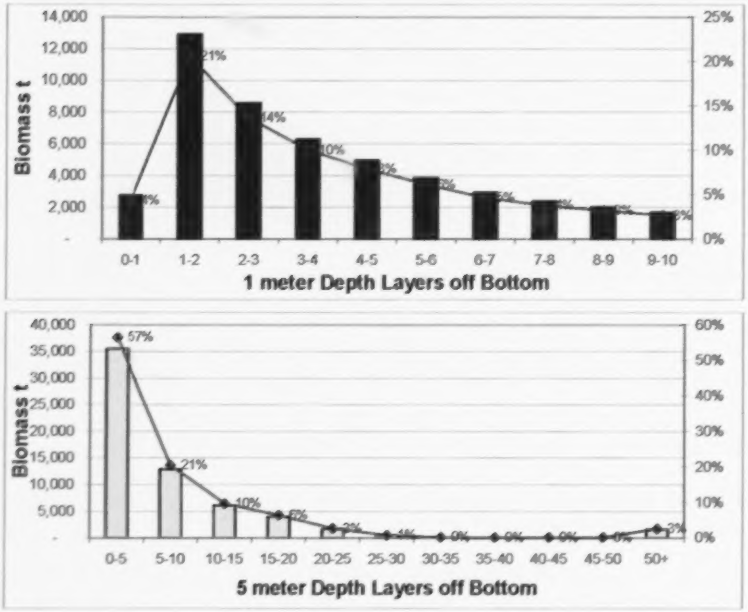
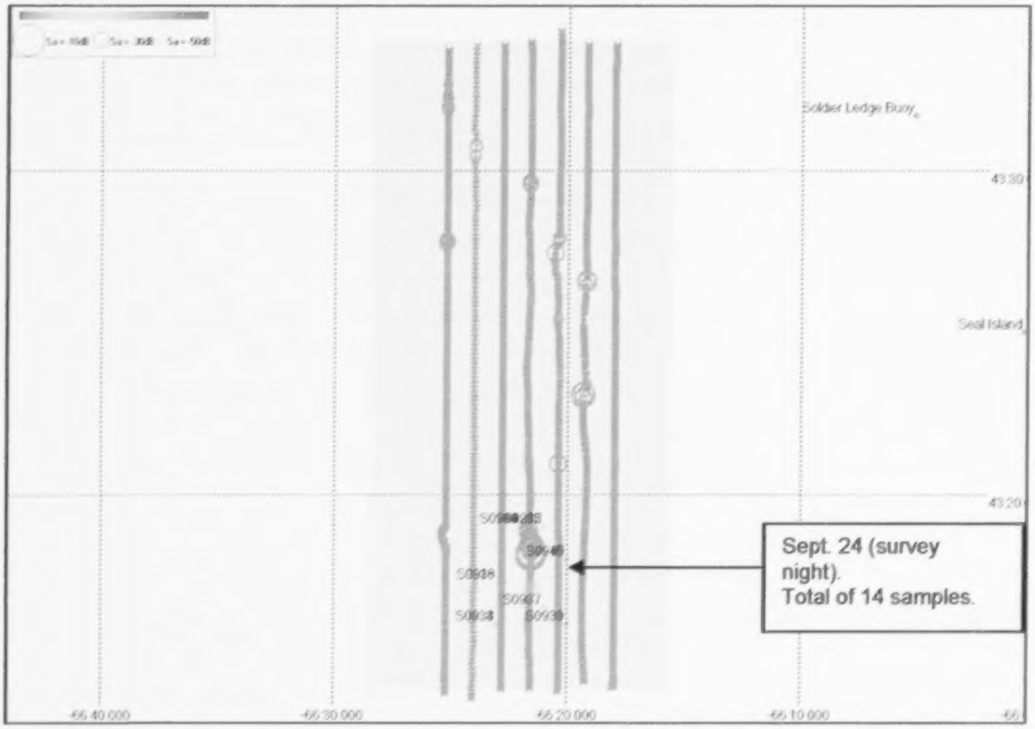


Figure 36. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey (#4) on September 15, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).


Soldier Ledge Buoy
43 30
Seal Island
43 20
-66 40.000
-66 30.000
-66 20.000
-66 10.000

Sept. 24 (survey night).
Total of 14 samples.

Figure 37. German Bank acoustic survey (#5) on September 23, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Sample locations are indicated by arrow for the general area and sample number.

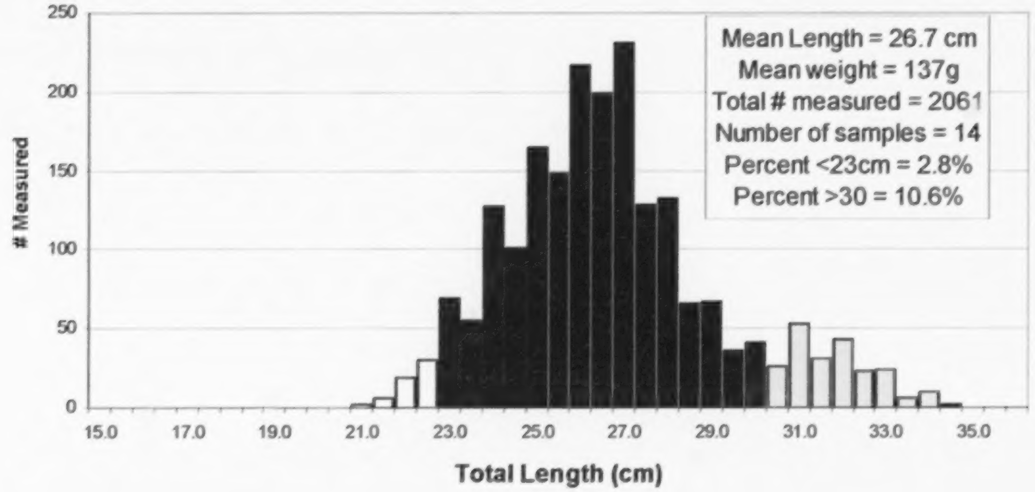


Figure 38. Length distribution used for calculation of TS for the German Bank acoustic survey (#5) on September 23, 2010, from sampling on September 24 with proportions <23cm and >30cm shown as white and grey bars.

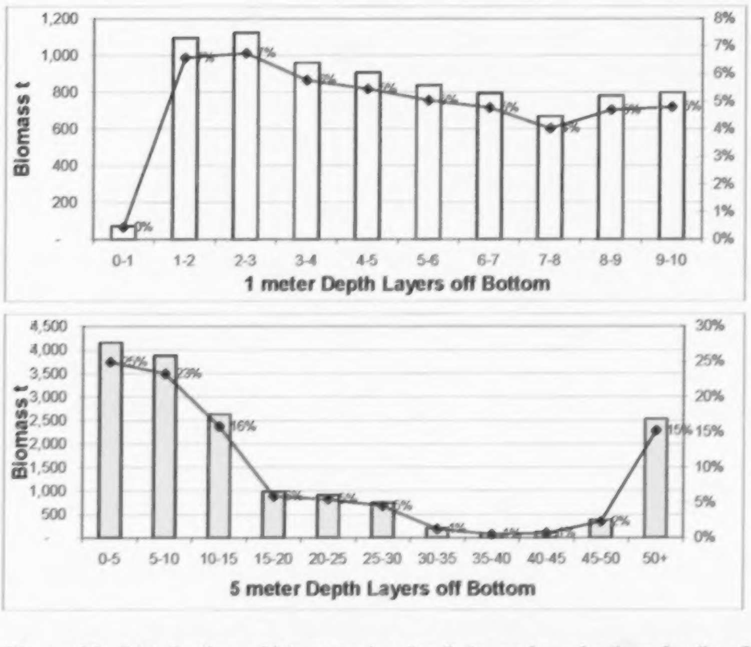


Figure 39. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey (#5) on September 23, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

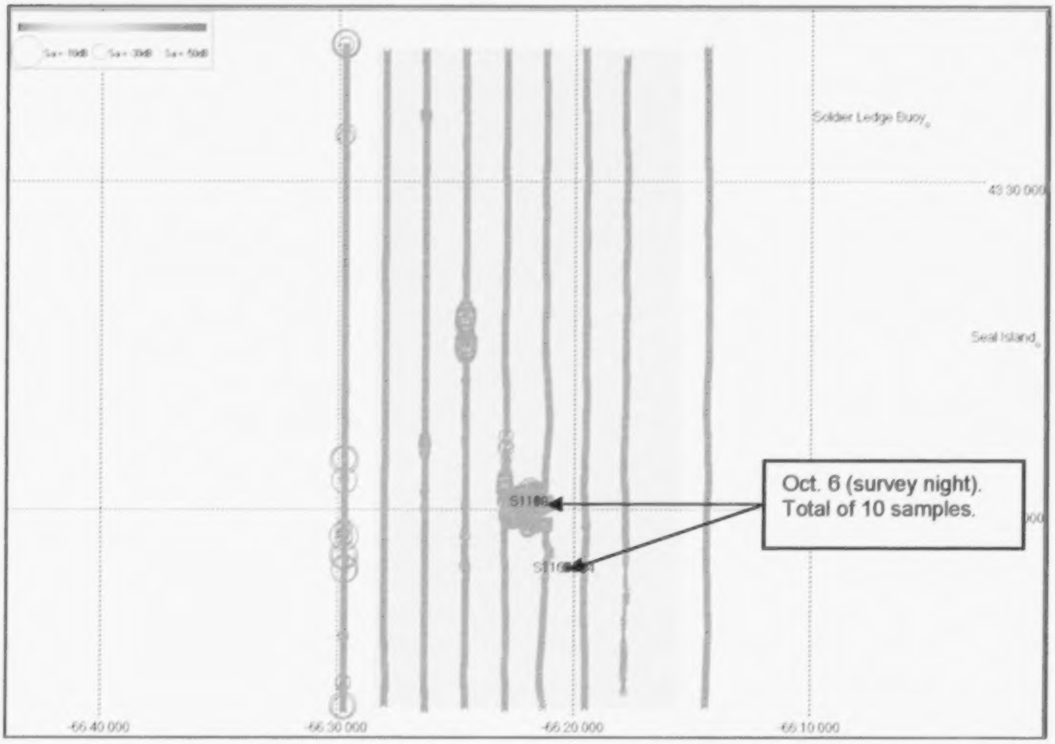

Sa = 10dB
Sa = 30dB
Sa = 50dB
Soldier Ledge Buoy
43 30 000
Seal Island
Oct. 6 (survey night).
Total of 10 samples.
-66 40 000
-66 30 000
-66 20 000
-66 10 000

Figure 40. German Bank acoustic survey on October 5, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Sample locations are indicated by arrows for the general area and sample number.

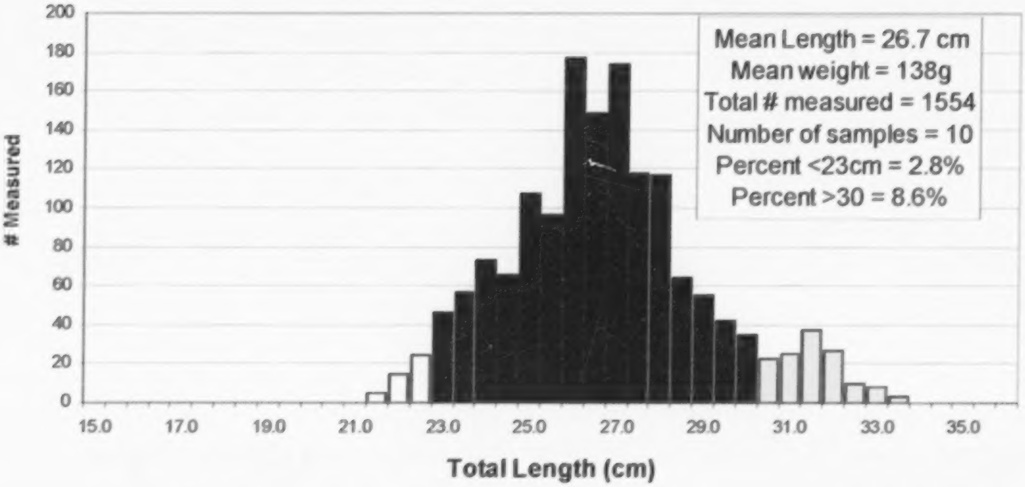


Figure 41. Length distribution used for calculation of TS for the German Bank acoustic survey (#6) on October 5, 2010, from sampling on October 6 with proportions <23cm and >30cm shown as white and grey bars.

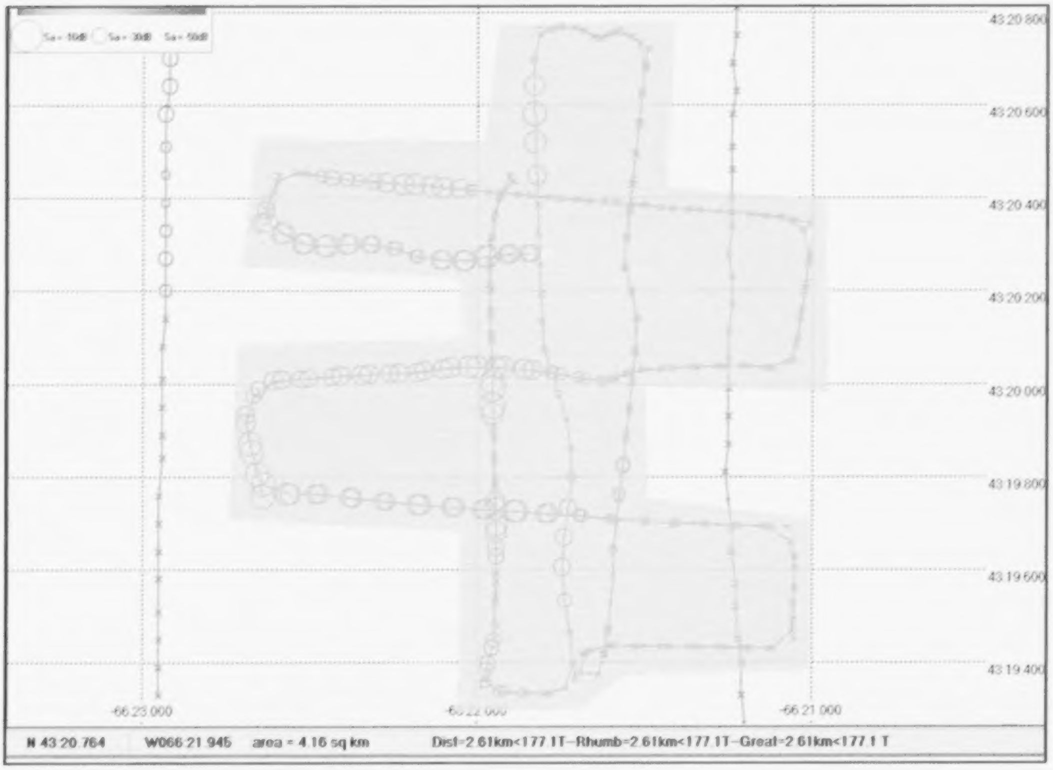

Sa = 10dB
Sa = 30dB
Sa = 50dB
43 20.800
43 20.600
43 20.400
43 20.200
43 20.000
43 19.800
43 19.600
43 19.400
-66 23.000
-66 22.000
-66 21.000
N 43 20.764
W066 21.945
area = 4.16 sq km
Dist=2.61km<177.1T–Rhumb=2.61km<177.1T–Great=2.61km<177.1 T

Figure 42. German Bank acoustic survey on October 5, 2010, showing additional lines completed on the main body of fish encountered between the survey lines (highlighted area with area estimate of 4.16 sq.km.).

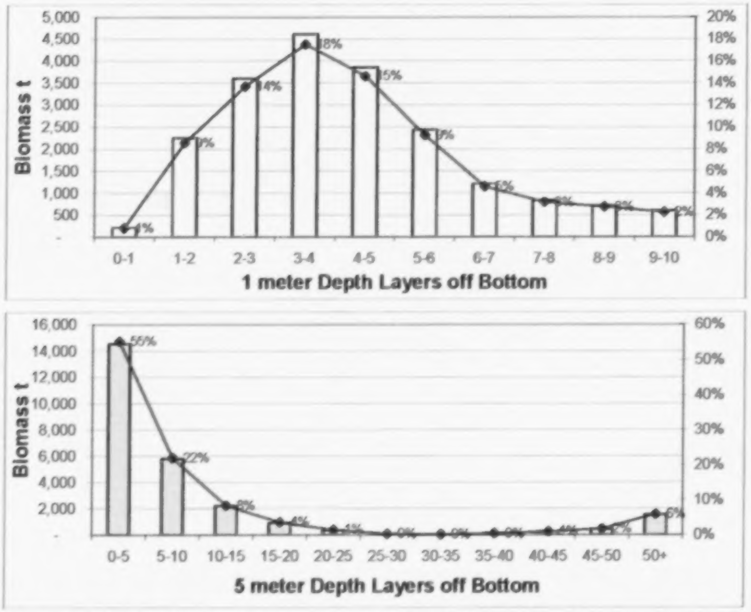


Figure 43. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey (#6) on October 5, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

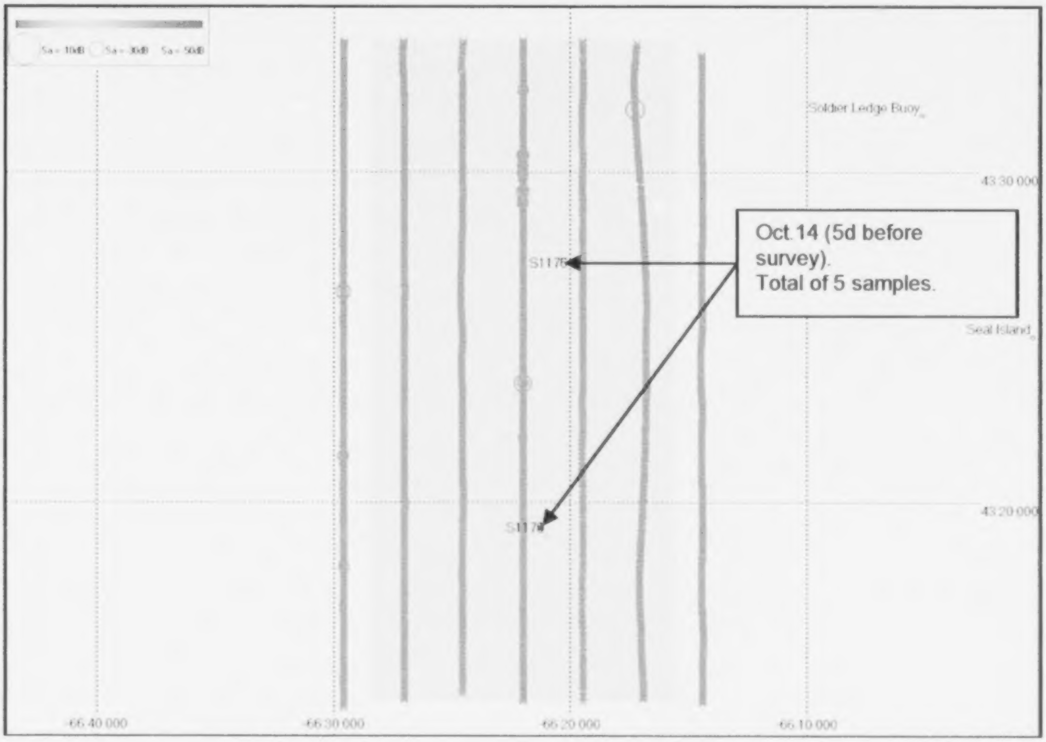

Sa = 10dB
Sa = 30dB
Sa = 50dB
Soldier Ledge Buoy
43 30 000
Oct.14 (5d before survey).
Total of 5 samples.
S1176
Seal Island
43 20 000
S1178
-66 40 000
-66 30 000
-66 20 000
-66 10 000

Figure 44. German Bank acoustic survey (#7) on October 19, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Sample locations are indicated by arrow for the general area and sample number.

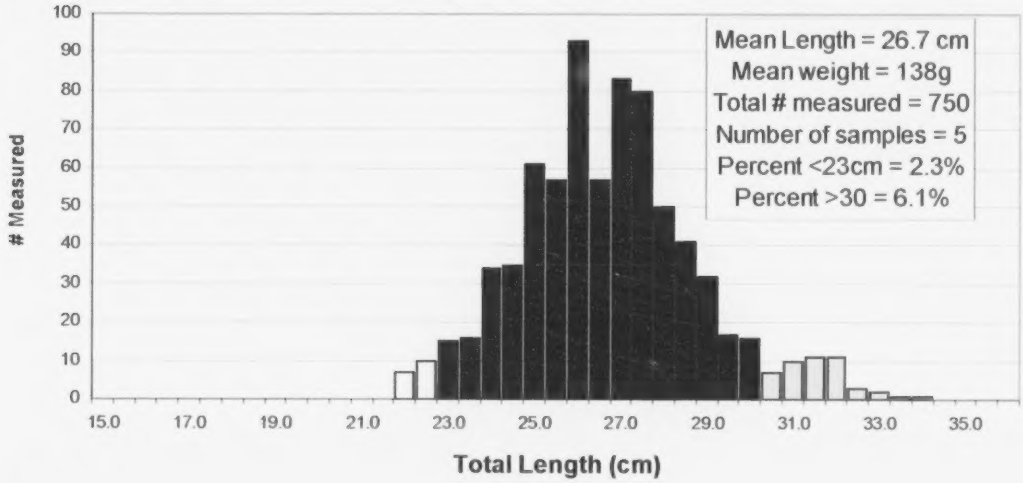


Figure 45. Length distribution used for calculation of TS for the German Bank acoustic survey (#7) on October 19, 2010, from sampling on October 14 with proportions <23cm and >30cm shown as white and grey bars.

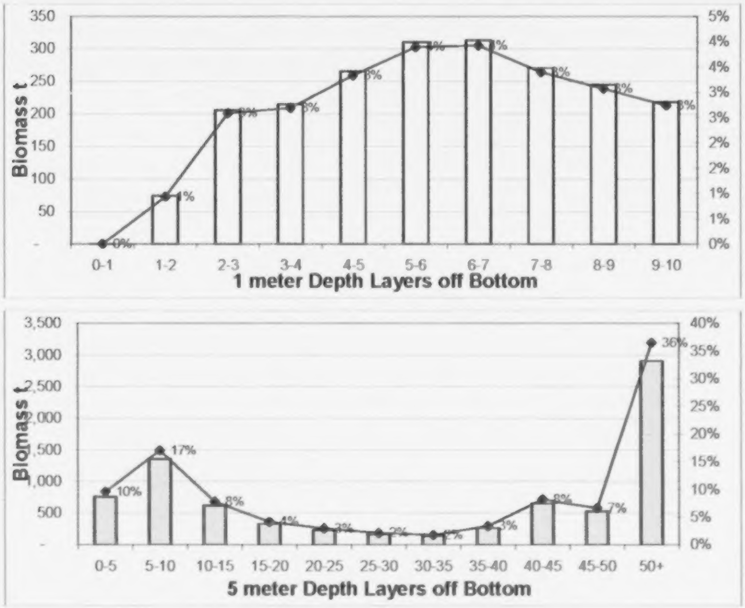
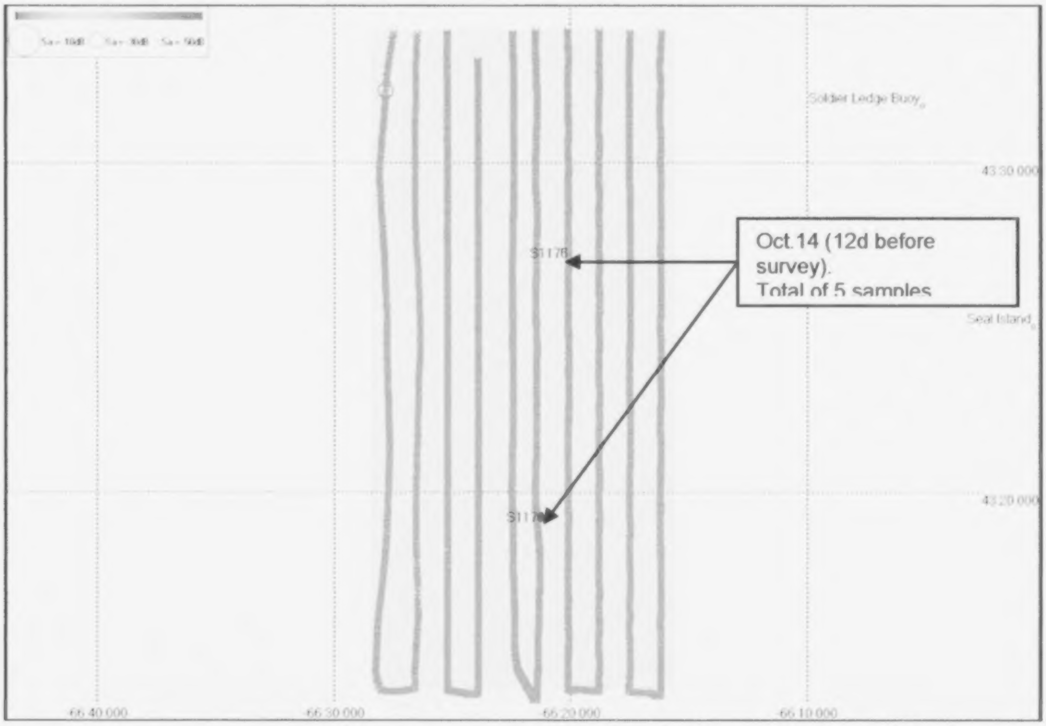


Figure 46. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey (#7) on October 19, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).


Sa = 10dB
Sa = 30dB
Sa = 50dB
Soldier Ledge Buoy
43 30.000
S1176
S1178
Seal Island
43 20.000
-66 40.000
-66 30.000
-66 20.000
-66 10.000

Oct.14 (12d before survey).
Total of 5 samples

Figure 47. German Bank acoustic survey on October 26, 2010, showing the main survey box (highlighted area) and transects with backscatter (Sa). Locations from October 14 fishery samples are indicated by arrow for the general area and sample number.

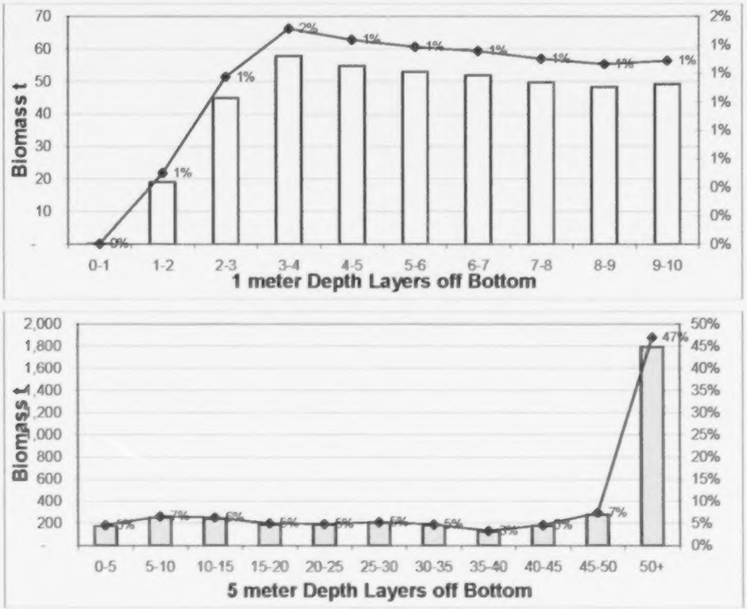


Figure 48. Distribution of biomass by depth layer from bottom for the German Bank acoustic survey (#8) on October 26, 2010. Biomass is shown as histogram bars and percent as a line for total biomass by 1m layers from 0m to 9m (top panel) and by 5m layers from bottom to surface (bottom panel).

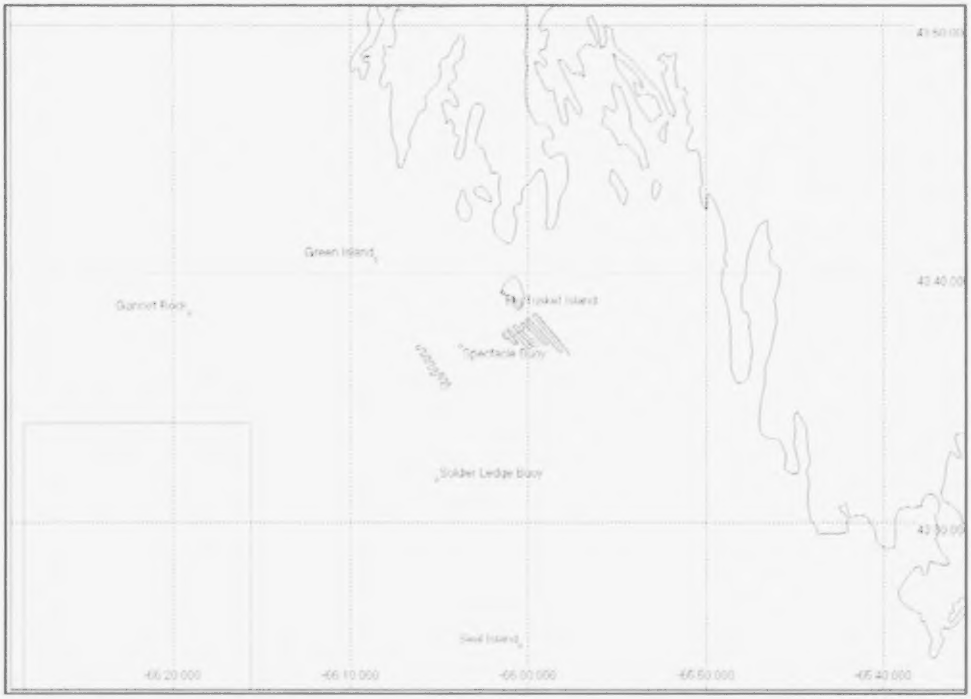

Green Island
Gannet Rock
Big Tusket Island
Spectacle Buoy
Soldier Ledge Buoy
Seal Island
43 50.000
43 40.000
43 30.000
-66 20.000
-66 10.000
-66 00.000
-65 50.000
-65 40.000

Figure 49. Spectacle Buoy area acoustic survey on June 2, 2010, showing tracks conducted by the vessel Wet & Wild.

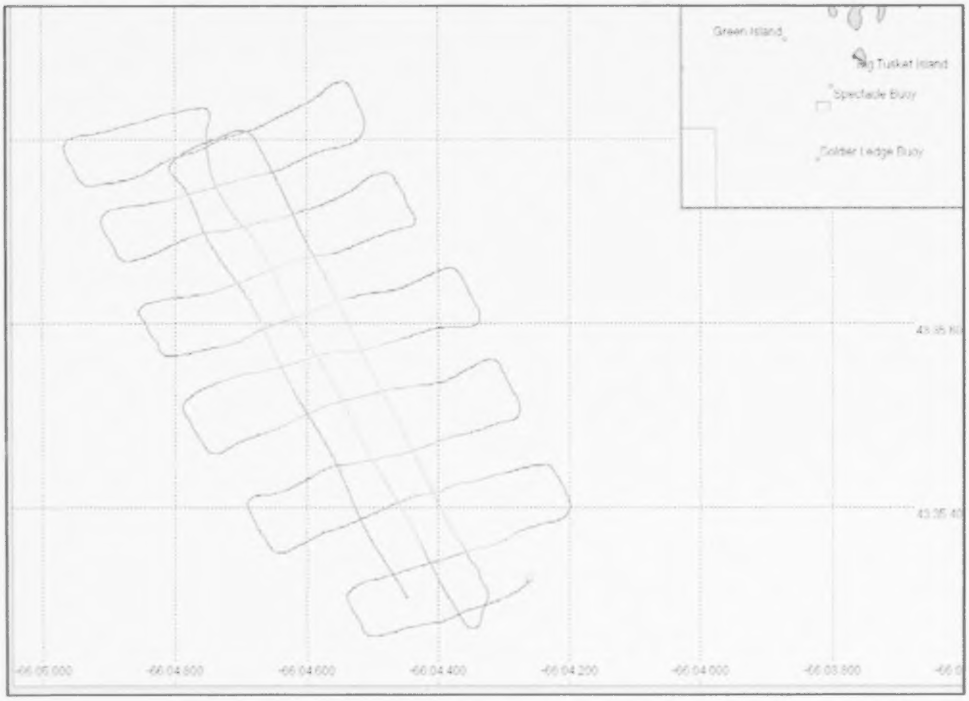

Green Island
Big Tusket Island
Spectacle Buoy
Soldier Ledge Buoy
43 35.60
43 35.40
-66 05.000
-66 04.800
-66 04.600
-66 04.400
-66 04.200
-66 04.000
-66 03.800

Figure 50. Spectacle Buoy area acoustic survey on June 4, 2010, showing detailed tracks conducted on the single school by the vessel Wet & Wild.

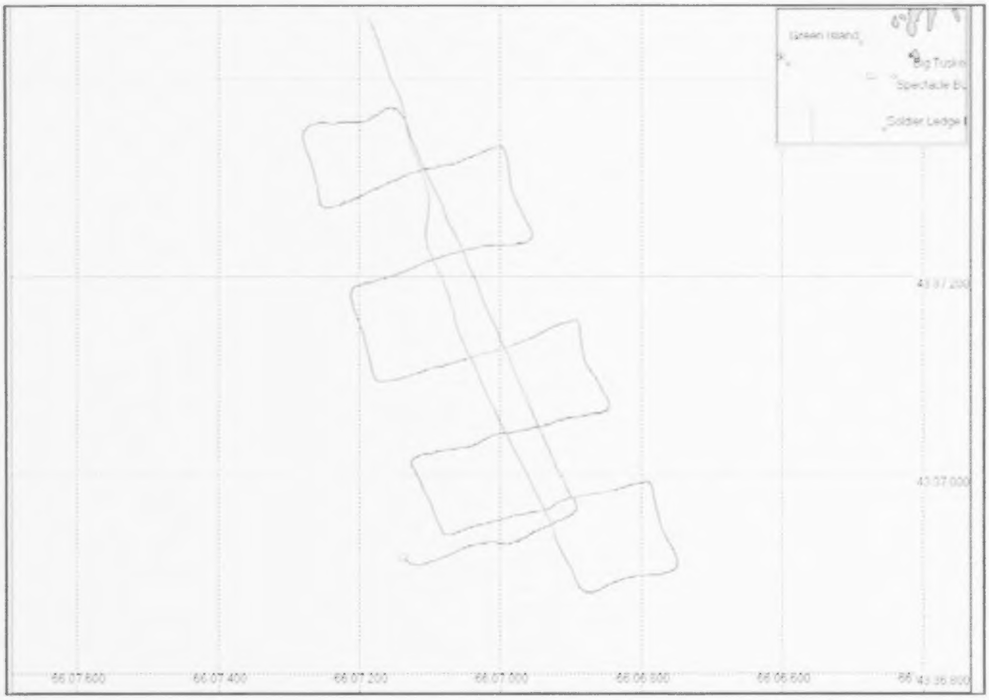

Green Island
Big Tusk
Spectacle B
Soldier Ledge
43 37.200
43 37.000
43 36.800
66 07.600
66 07.400
66 07.200
66 07.000
66 06.800
66 06.600

Figure 51. Spectacle Buoy area acoustic survey on June 17, 2010, showing tracks conducted by the vessel Wet & Wild.

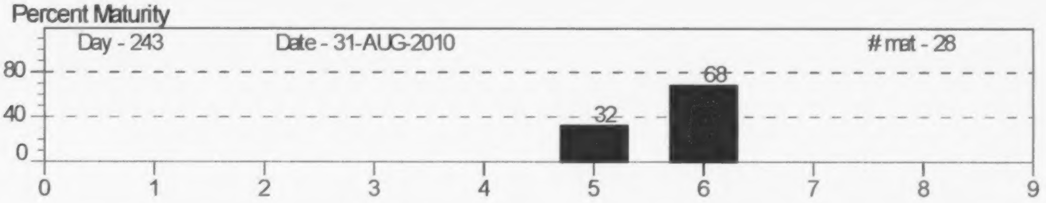


Figure 52. Herring maturity sample collected from the Trinity Ledge area in 2010. (Staging codes 1-2=immature; 3-4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering).

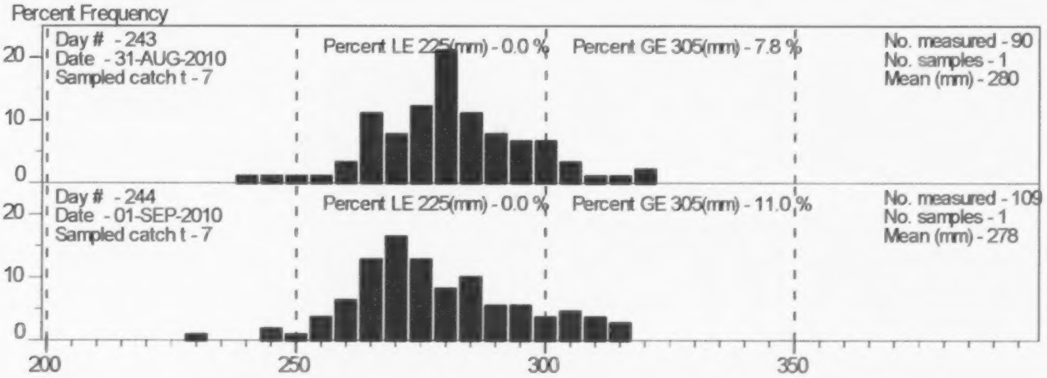


Figure 53. Daily herring length frequency samples collected from the Trinity Ledge gillnet fishery in 2010 with proportions <23cm and >30cm.

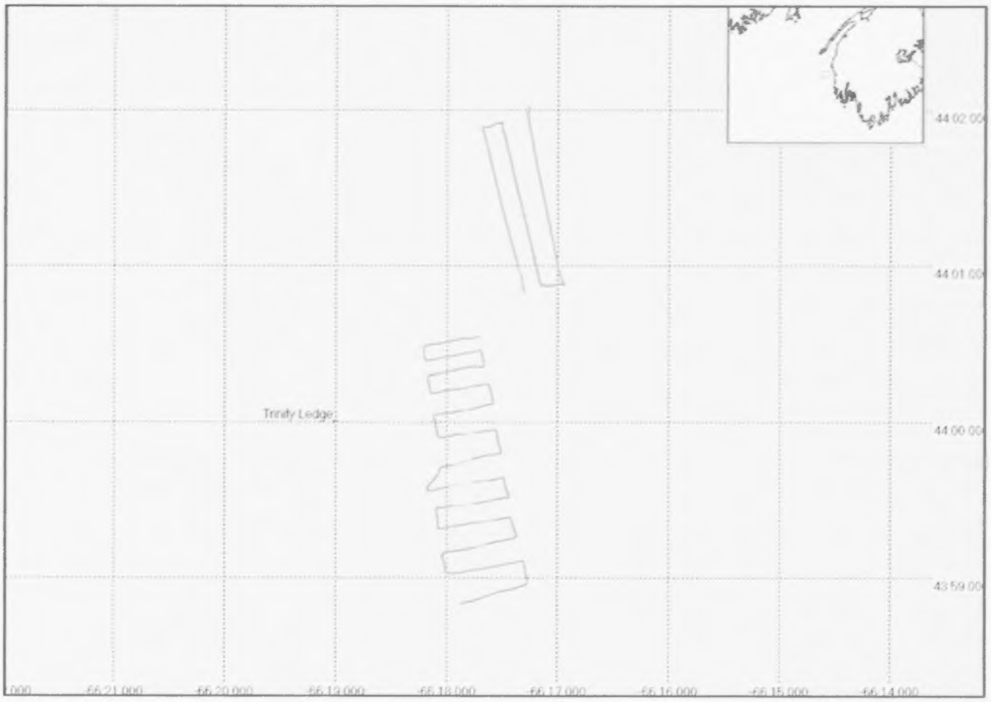

Trinity Ledge
44 02 0
44 01 0
44 00 0
43 59 0
000
-66 21.000
-66 20.000
-66 19.000
-66 18.000
-66 17.000
-66 16.000
-66 15.000
-66 14.000

Figure 54. 2010 Trinity Ledge area herring acoustic survey on August 19, 2010, showing tracks conducted by the vessel Wet & Wild.

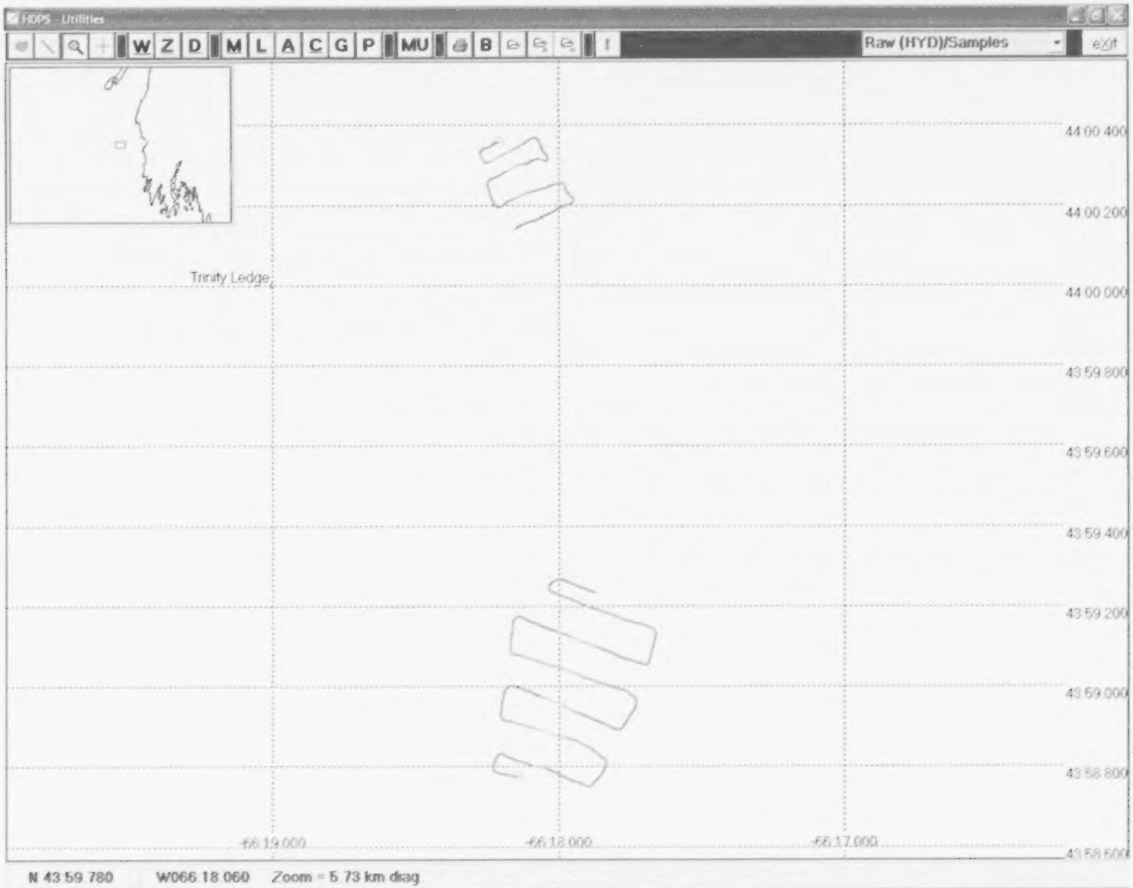

HDPS - Utilities
W Z D M L A C G P MU B !
Raw (HYD)/Samples
exit
Trinity Ledge
44 00.400
44 00.200
44 00.000
43 59.800
43 59.600
43 59.400
43 59.200
43 59.000
43 58.800
43 58.600
-66 19.000
-66 18.000
-66 17.000
N 43 59.780
W066 18.060
Zoom = 5.73 km diag

Figure 55. 2010 Trinity Ledge area herring acoustic survey on August 29, 2010, showing tracks conducted by the vessel Wet & Wild.

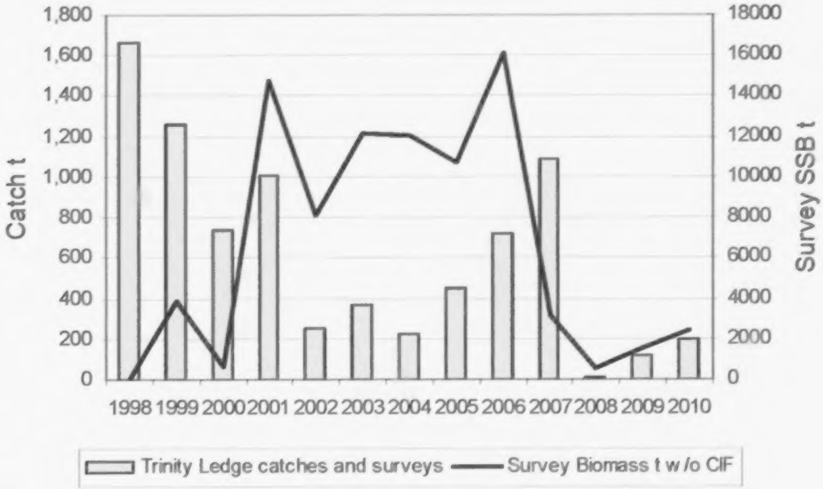


Figure 56. Trinity Ledge herring catches and acoustic survey biomass estimates from 1998 to 2010. All acoustic estimates were calculated with the CIF.

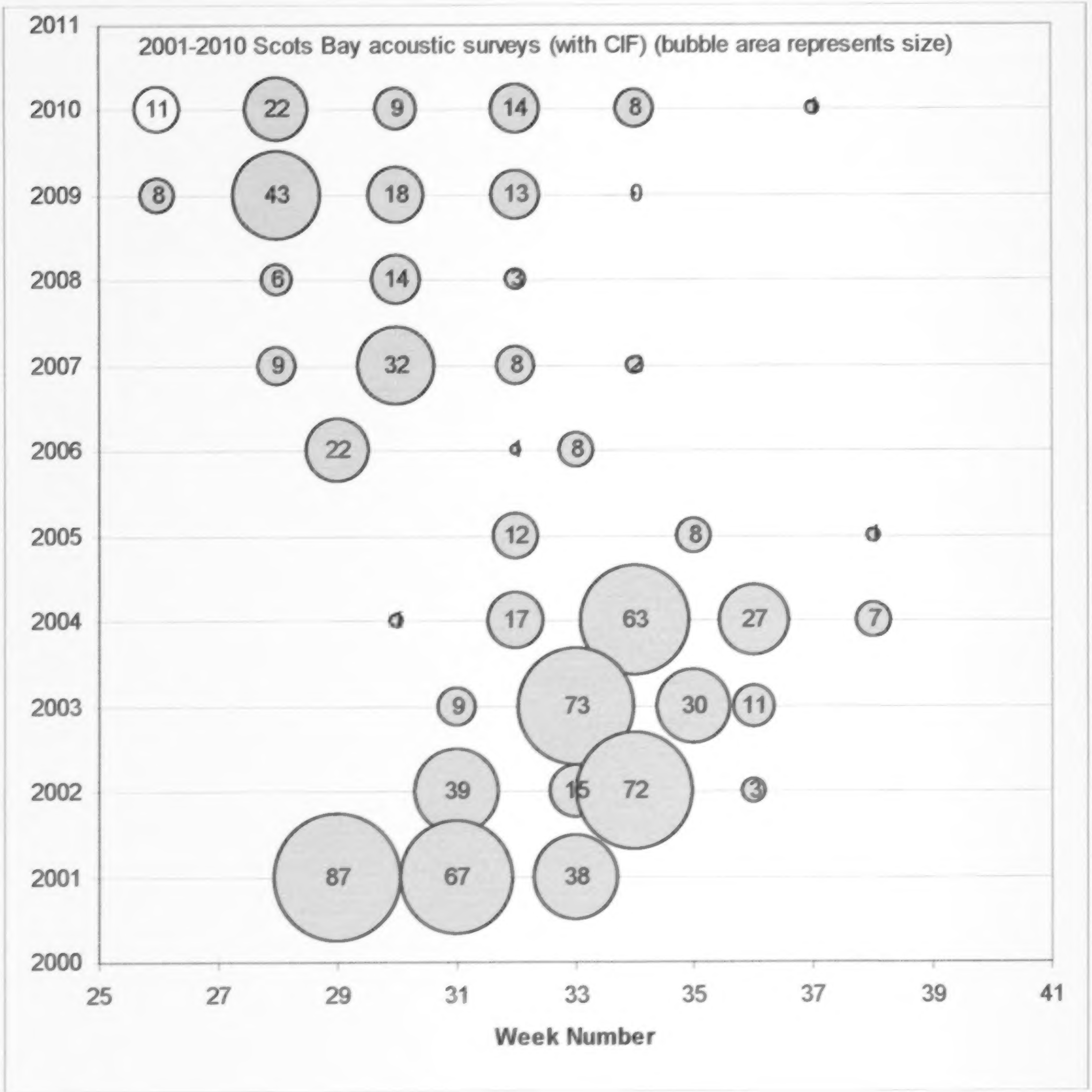


Figure 57. History of Scots Bay herring acoustic surveys from 2001 to 2010 by week number showing timing with bubble area representing biomass (in thousands) for each survey (calculated *with* *CIF).*

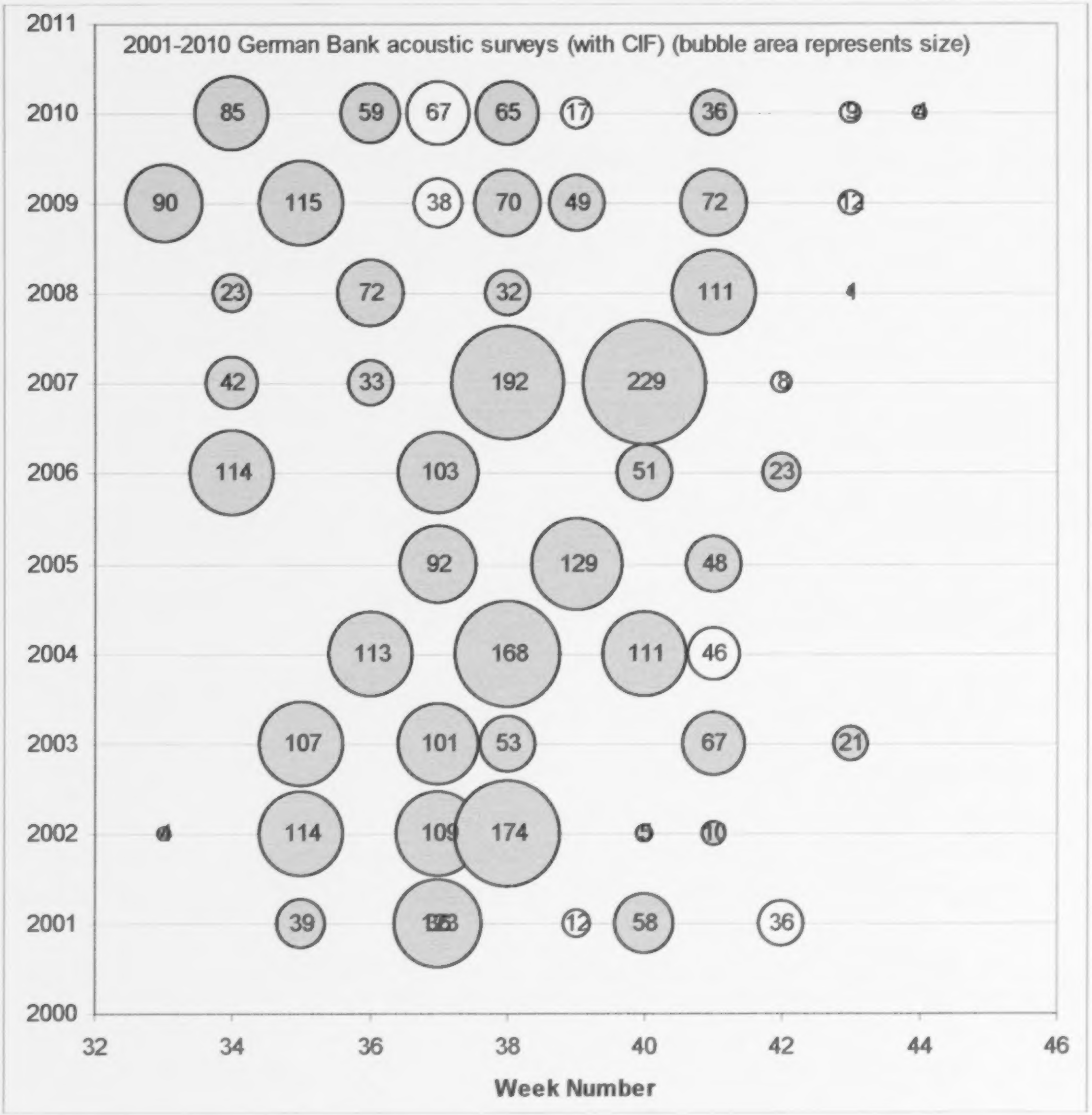


Figure 58. History of German Bank herring acoustic surveys from 2001 to 2010 by week number showing timing with bubble area representing biomass (in thousands) for each survey (calculated with CIF).

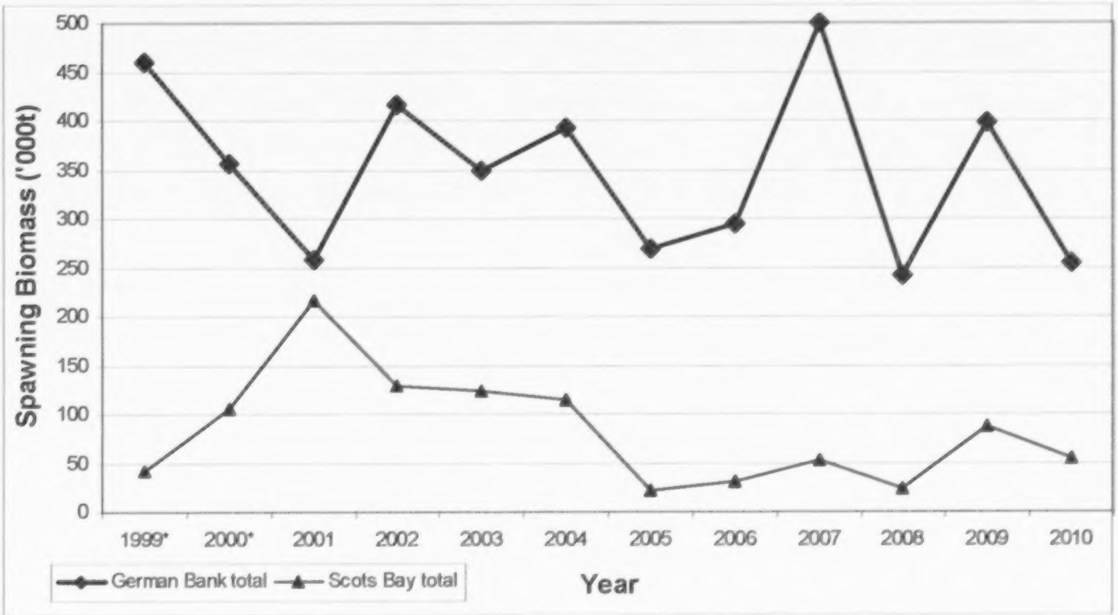


Figure 59. Trends in herring spawning stock biomass from acoustic surveys in Scots Bay and German Bank areas. Biomass estimates for 1997 and 1998 are not considered comparable due to variation in the coverage area. 1997 to 2000 estimates calculated 'without' CIF.

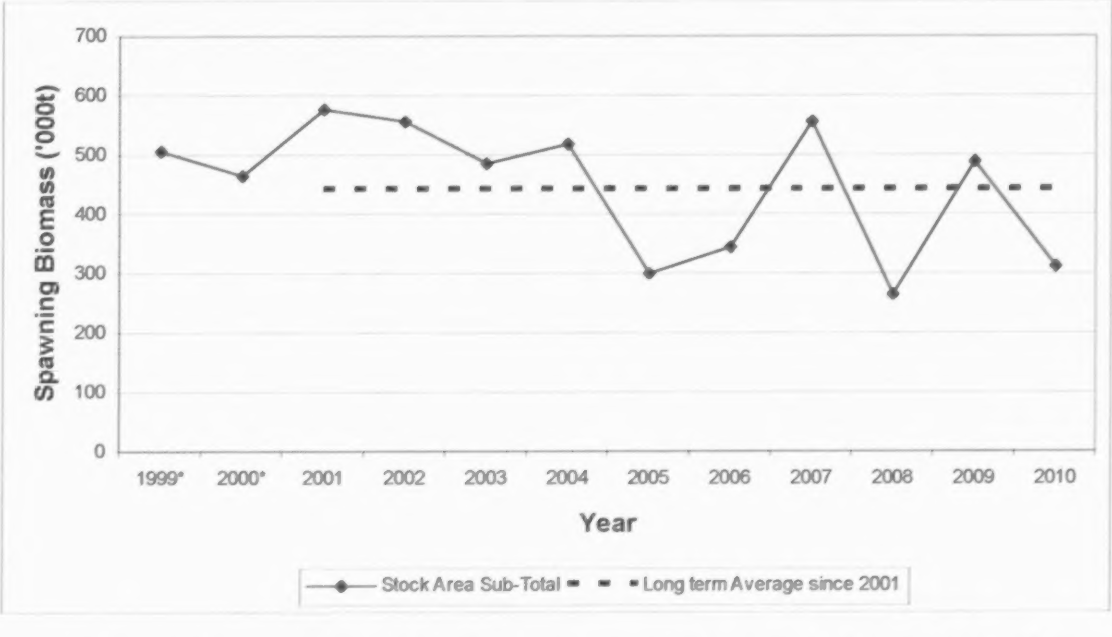


Figure 60. Trends in herring spawning stock biomass from acoustic surveys for the combined SWNS areas with 95% confidence intervals and the long term average SSB since 2001. Biomass estimates for 1997 and 1998 are not considered comparable due to variation in the coverage area. 1997 to 2000 estimates calculated 'without' CIF.

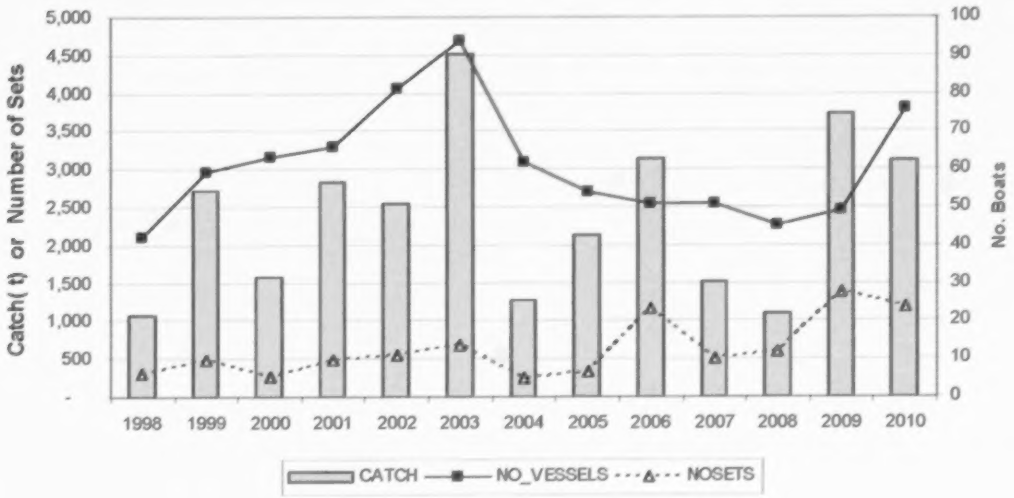


Figure 61. 1998-2010 herring gillnet total catch (t) and total effort in number of vessels and number of sets for the Little Hope/Port Mouton area.

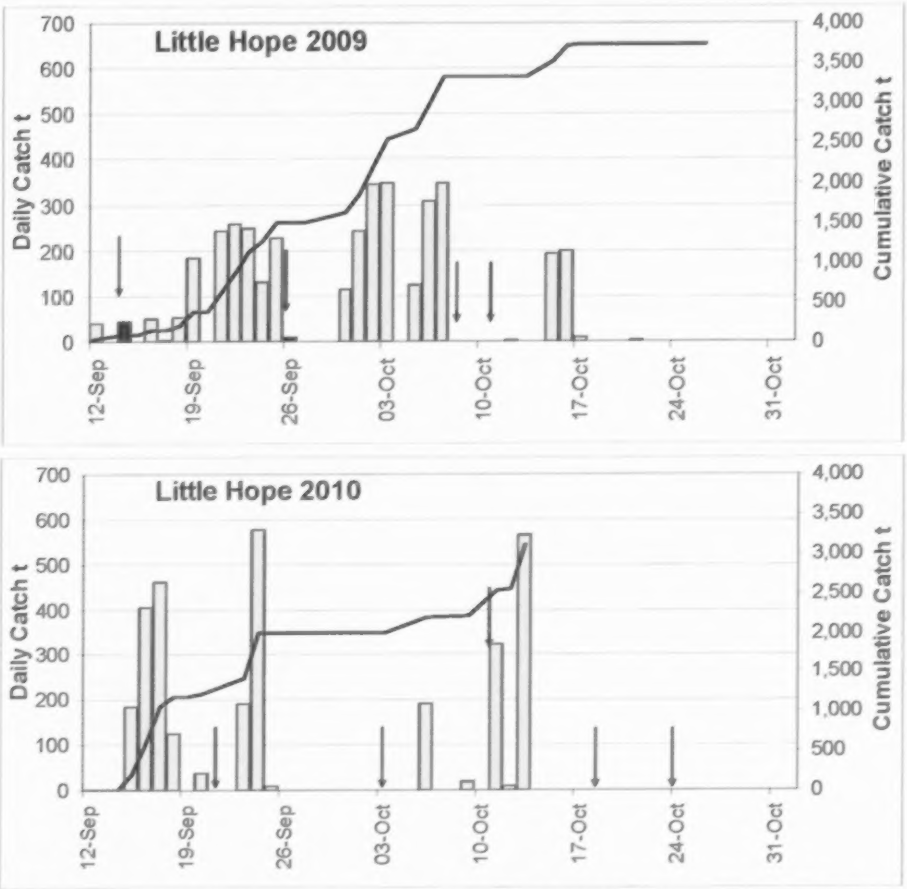


Figure 62. Daily and cumulative catch for the 2010-2010 Little Hope/Port Mouton herring gillnet fishery. Survey dates are identified by black columns or arrows indicating survey timing.

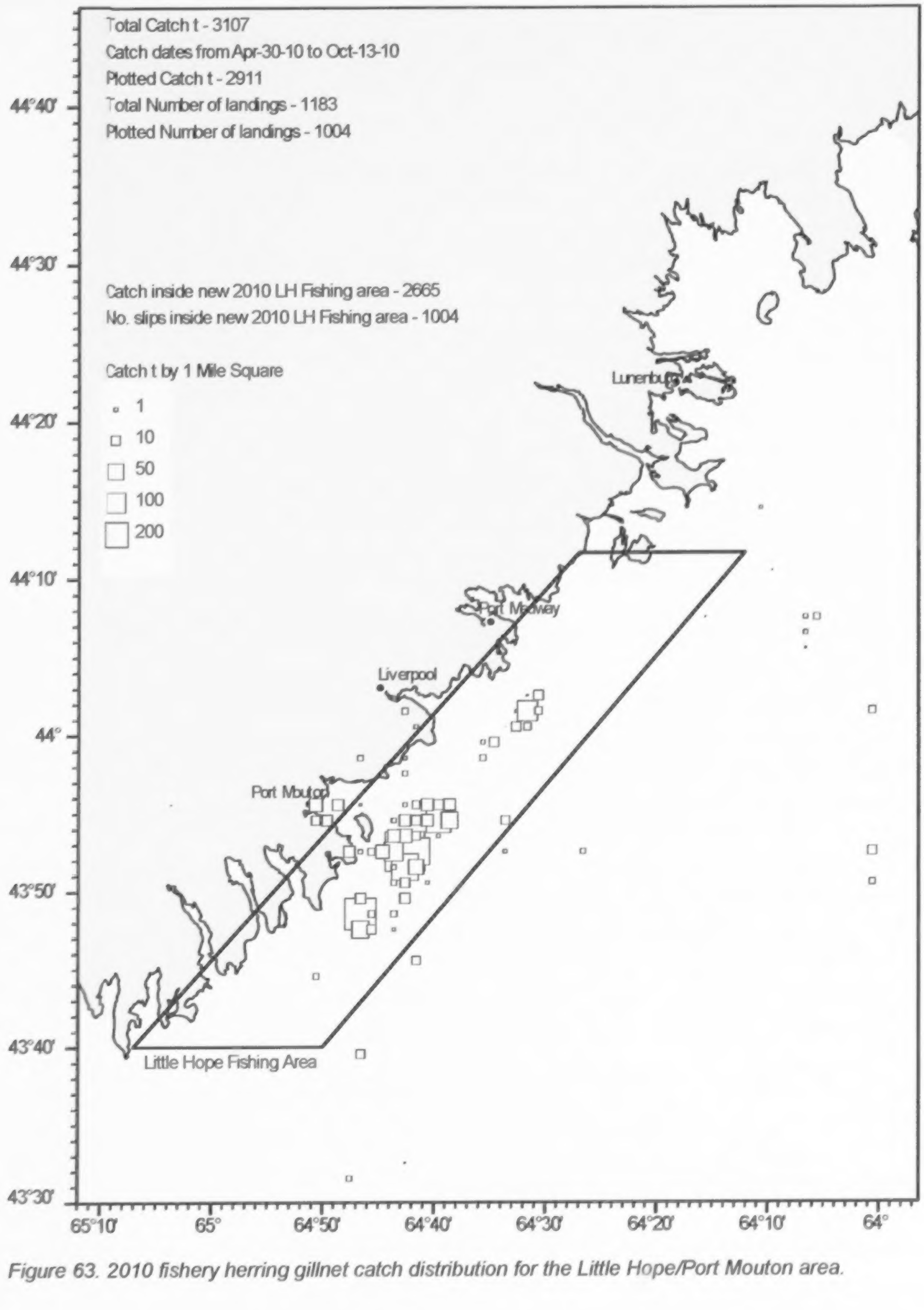

Total Catch t - 3107
Catch dates from Apr-30-10 to Oct-13-10
Plotted Catch t - 2911
Total Number of landings - 1183
Plotted Number of landings - 1004
Catch inside new 2010 LH Fishing area - 2665
No. slips inside new 2010 LH Fishing area - 1004
Catch t by 1 Mile Square
1
10
50
100
200
Lunenburg
Port Medway
Liverpool
Port Mouton
Little Hope Fishing Area
44°40'
44°30'
44°20'
44°10'
44°
43°50'
43°40'
43°30'
65°10'
65°
64°50'
64°40'
64°30'
64°20'
64°10'
64°

Figure 63. 2010 fishery herring gillnet catch distribution for the Little Hope/Port Mouton area.

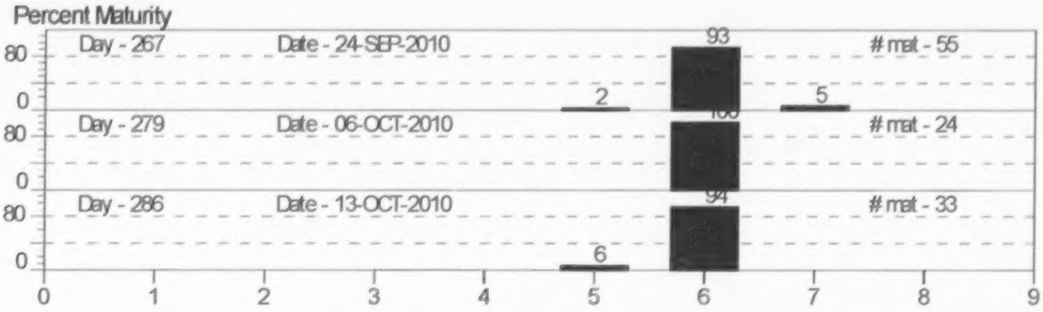


Figure 64. 2010 Port Mouton/Little Hope maturity sampling from gillnet commercial landings. (Staging codes 1-2=immature; 3-4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering).

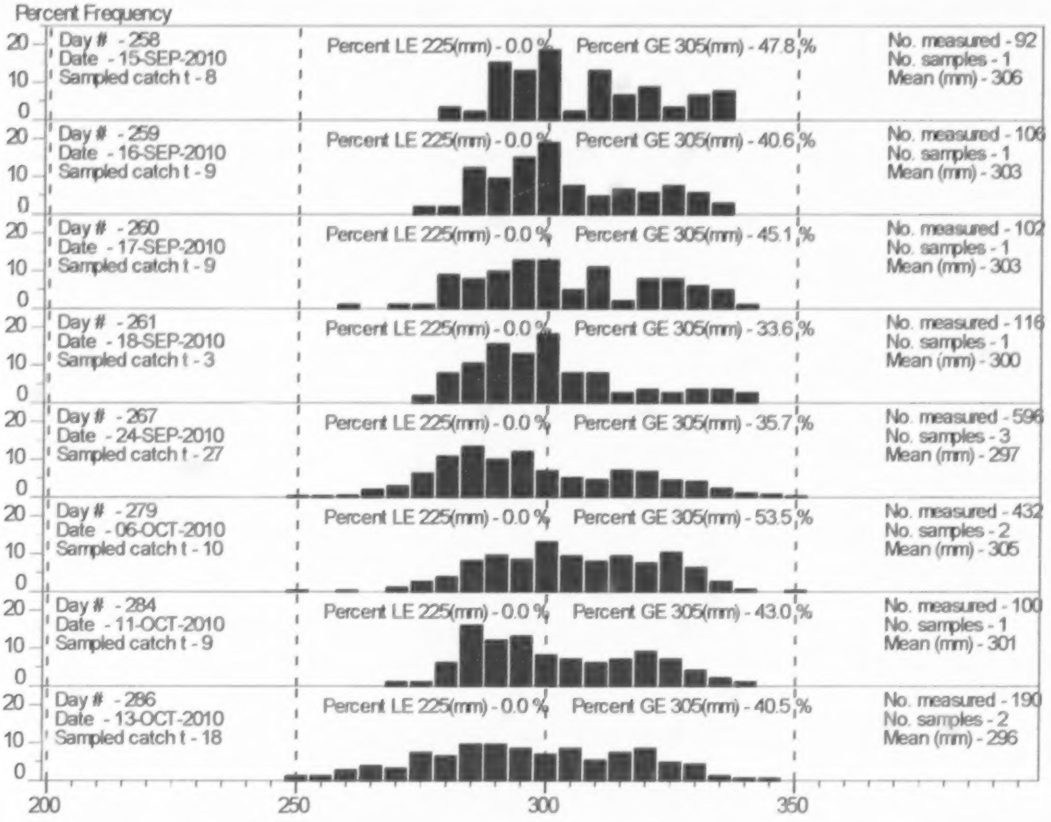


Figure 65. 2010 Port Mouton/Little Hope daily length frequency sampling from gillnet commercial landings from September 15 to October 13 with proportions <23cm and >30cm.

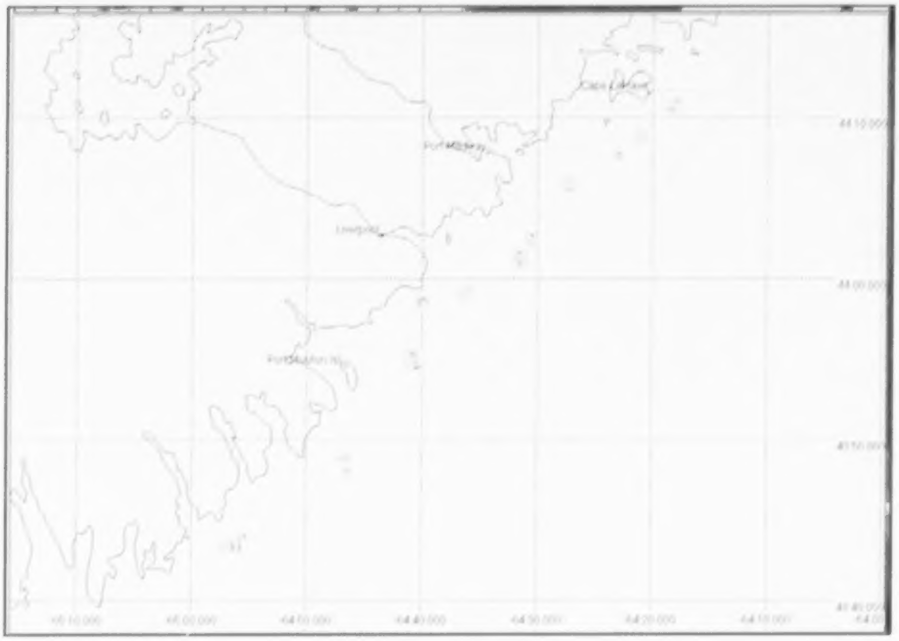


Figure 66. Little Hope/Port Mouton herring gillnet survey (#1) on Sept 21, 2010, showing transects for each of the school areas and the overall spawning box area.

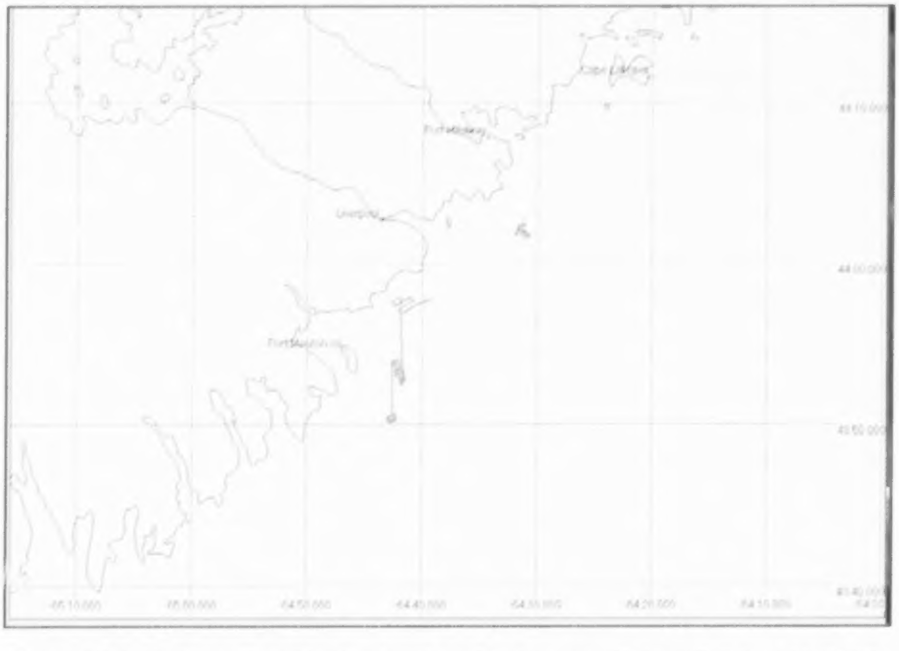


Figure 67. Little Hope/Port Mouton herring gillnet survey (#2) on October 11, 2010, showing transects for each of the school areas and the overall spawning box area.

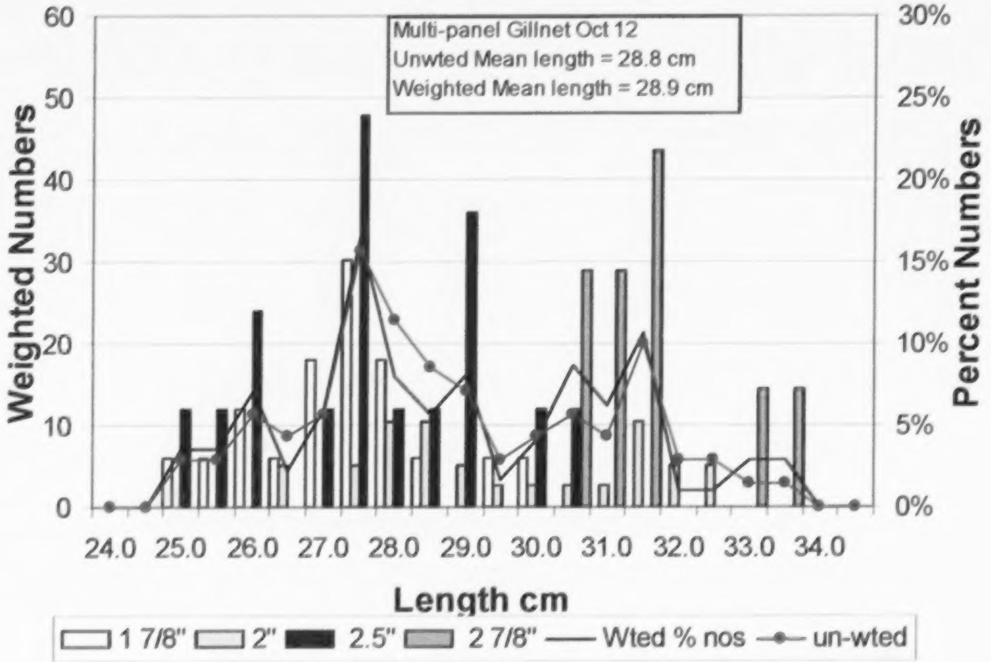


Figure 68. Multi-panel herring gillnet sample collected on October 12, 2010, for Little Hope/Port Mouton herring gillnet survey (#2) on October 11, 2011.

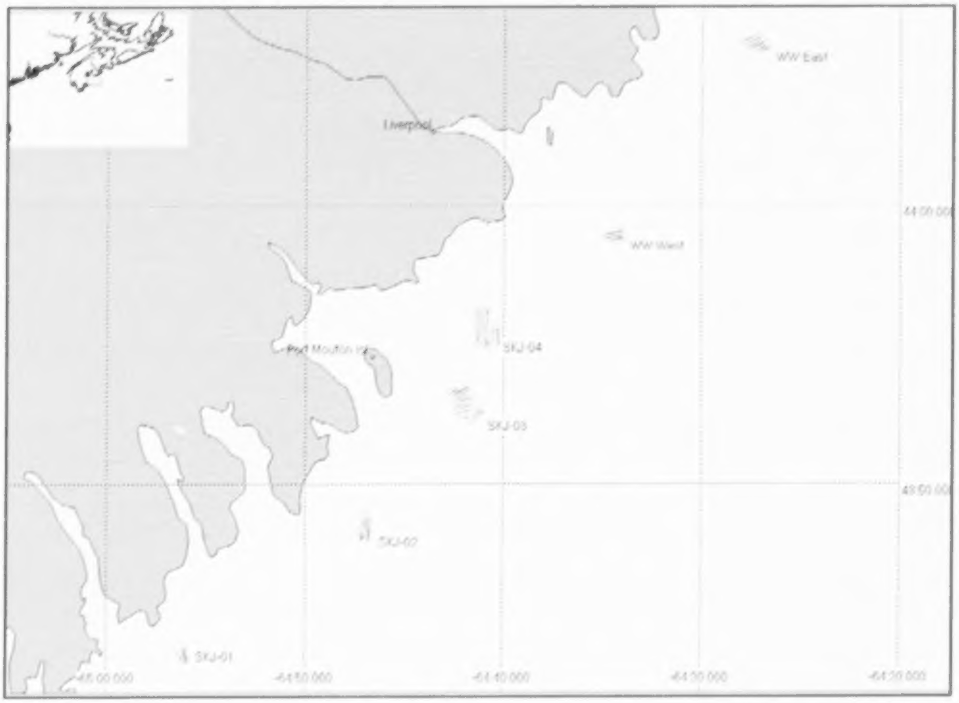

WW East
Liverpool
44 00 000
WW West
SKJ-04
Port Mouton Isl
SKJ-03
43 50 000
SKJ-02
SKJ-01
-65 00 000
-64 50 000
-64 40 000
-64 30 000
-64 20 000

Figure 69. Little Hope/Port Mouton herring gillnet survey (#3) on October 19, 2010, showing transects for each of the school areas.

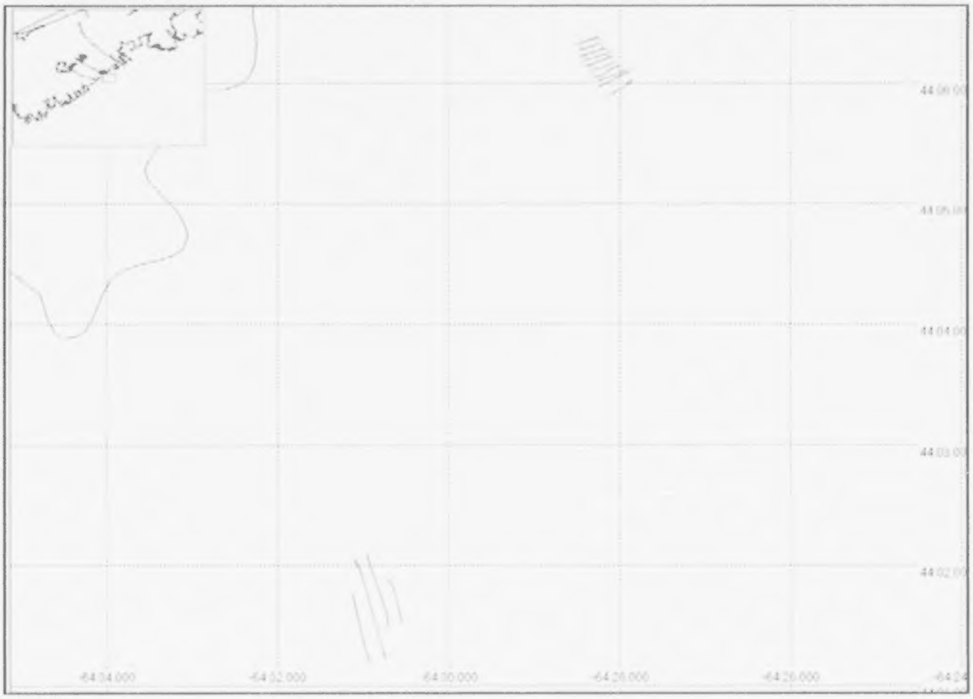

44 06 00
44 05 00
44 04 00
44 03 00
44 02 00
-64 34.000
-64 32.000
-64 30.000
-64 28.000
-64 26.000
-64 24

Figure 70. Little Hope/Port Mouton herring gillnet survey (#4) on October 25, 2010, showing transects for each of the school areas.

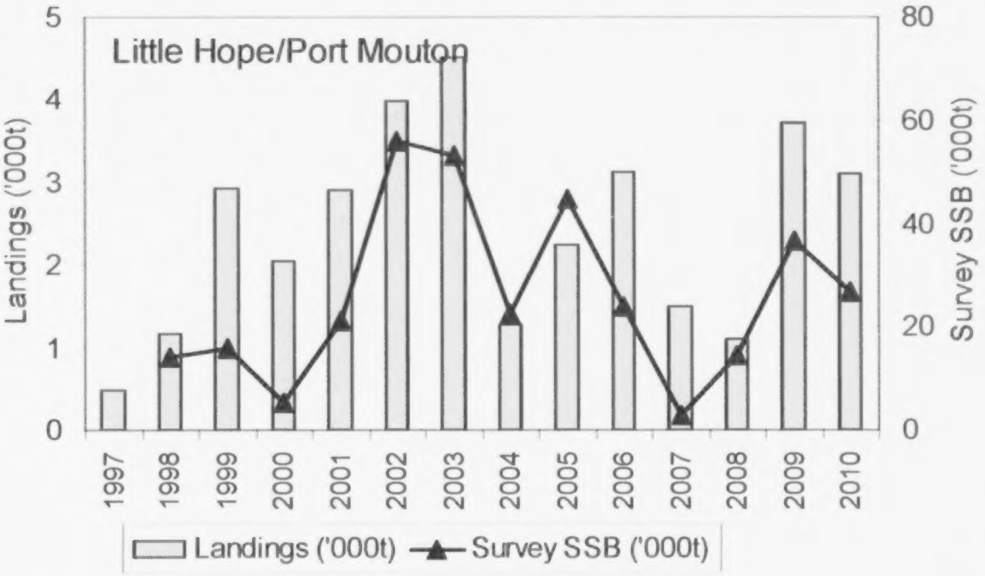


Figure 71. Little Hope/Port Mouton herring catches and acoustic survey biomass estimates from 1997 to 2010. (Acoustic survey SSB 1998-2002 'without' the CIF; 2003-2010 with the CIF).

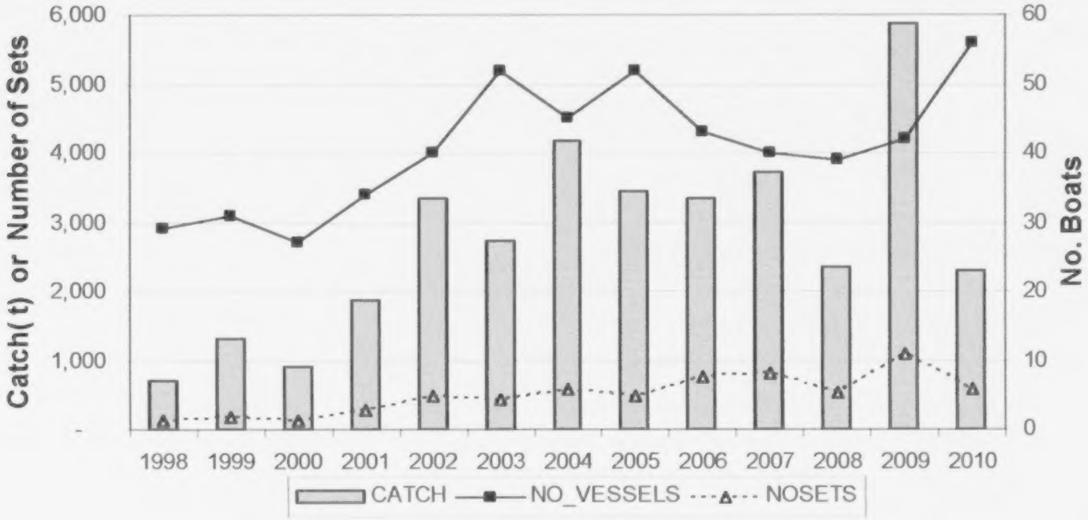


Figure 72. 1998-2010 herring gillnet total catch (t) and total effort in number of vessels and number of sets for the Halifax/Eastern Shore area.

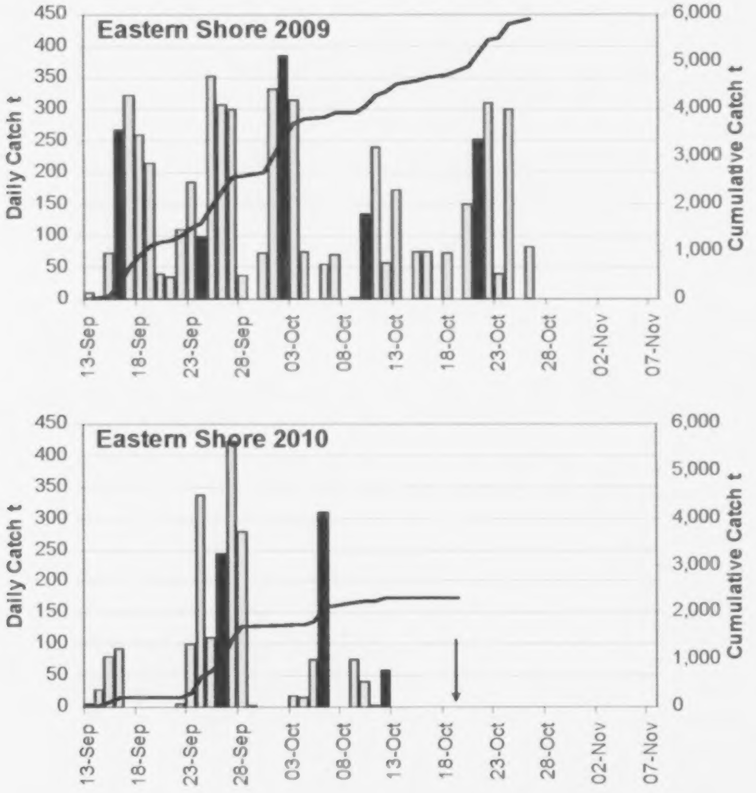


Figure 73. Daily and cumulative catch for the 2010-2010 Halifax/Eastern Shore herring gillnet fishery. Survey dates are identified by black columns or arrows indicating time of survey.

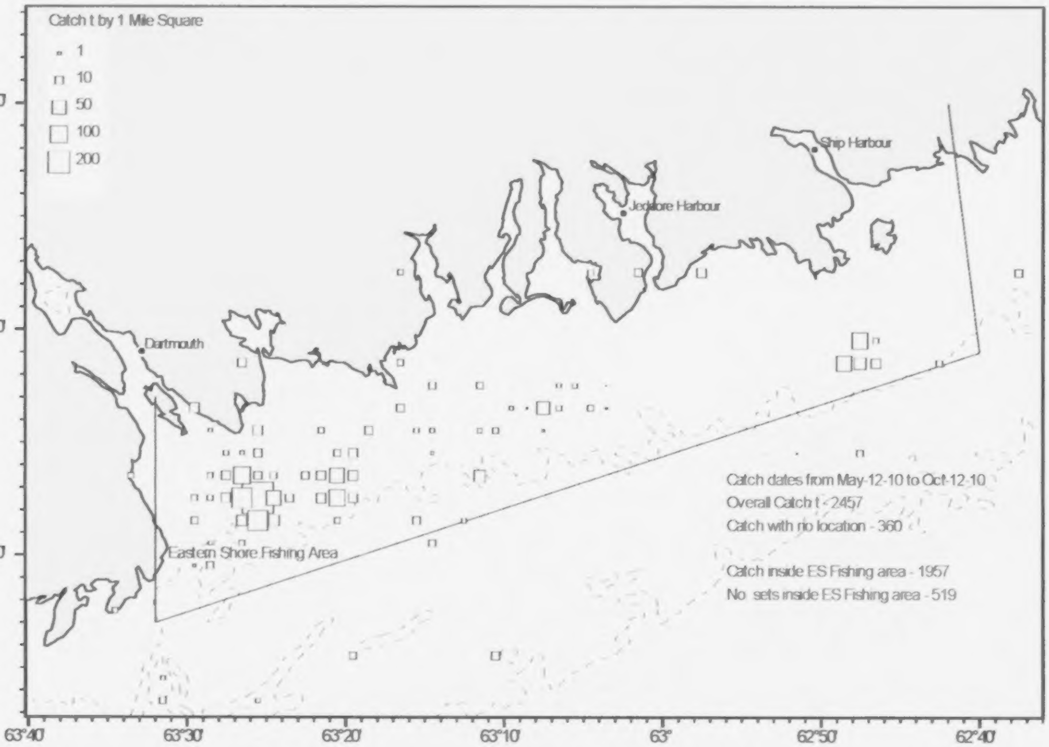

Catch t by 1 Mile Square
1
10
50
100
200
Ship Harbour
Jeddore Harbour
Dartmouth
Eastern Shore Fishing Area
Catch dates from May-12-10 to Oct-12-10
Overall Catch t - 2457
Catch with no location - 360
Catch inside ES Fishing area - 1957
No. sets inside ES Fishing area - 519
44°50'
44°40'
44°30'
63°40'
63°30'
63°20'
63°10'
63°
62°50'
62°40'

Figure 74. 2010 herring fishery gillnet catches for the Halifax/Eastern Shore area.

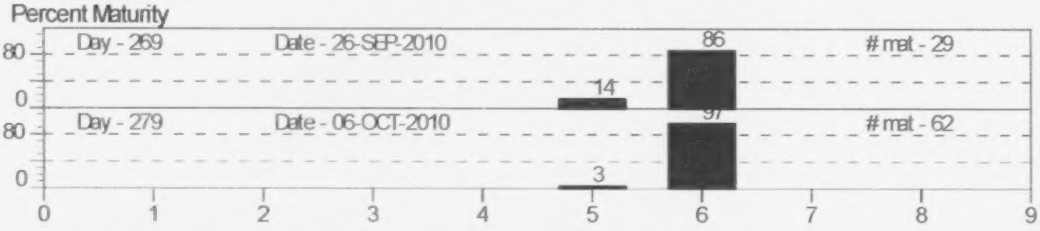


Figure 75. 2010 Halifax/Eastern Shore herring maturity sample data from gillnet multi-panel nets. (Staging codes 1-2=immature; 3-4-5=maturing/hard; 6=ripe and running; 7=spent; 8=recovering).

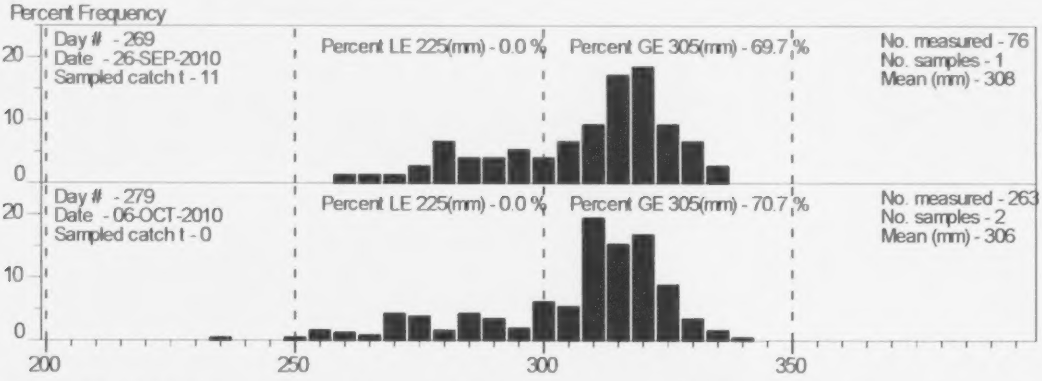


Figure 76. 2010 Halifax/Eastern Shore daily length frequency sampling from multi-panel gillnet samples with proportions <23cm and >30cm.

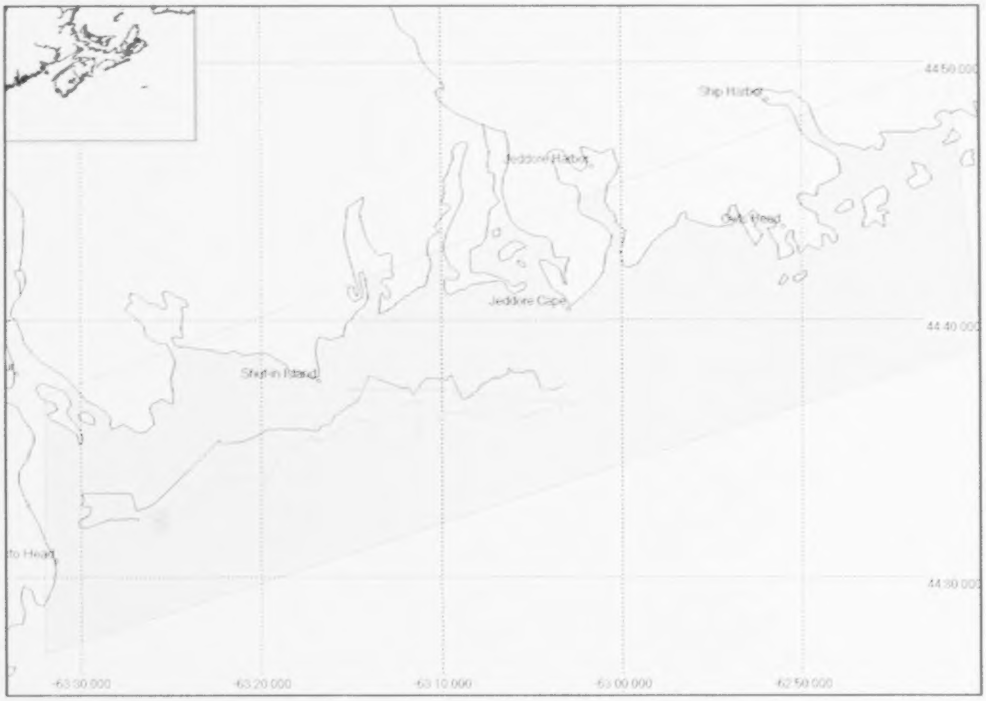

Ship Harbour
Jeddore Harbour
Owls Head
Jeddore Cape
Shut-in Island
44 50.000
44 40.000
44 30.000
-63 30.000
-63 20.000
-63 10.000
-63 00.000
-62 50.000

Figure 77. Halifax/Eastern Shore acoustic survey transects for September 26 survey conducted by two acoustic survey vessels, the Bradley K and the Miss Owls Head.

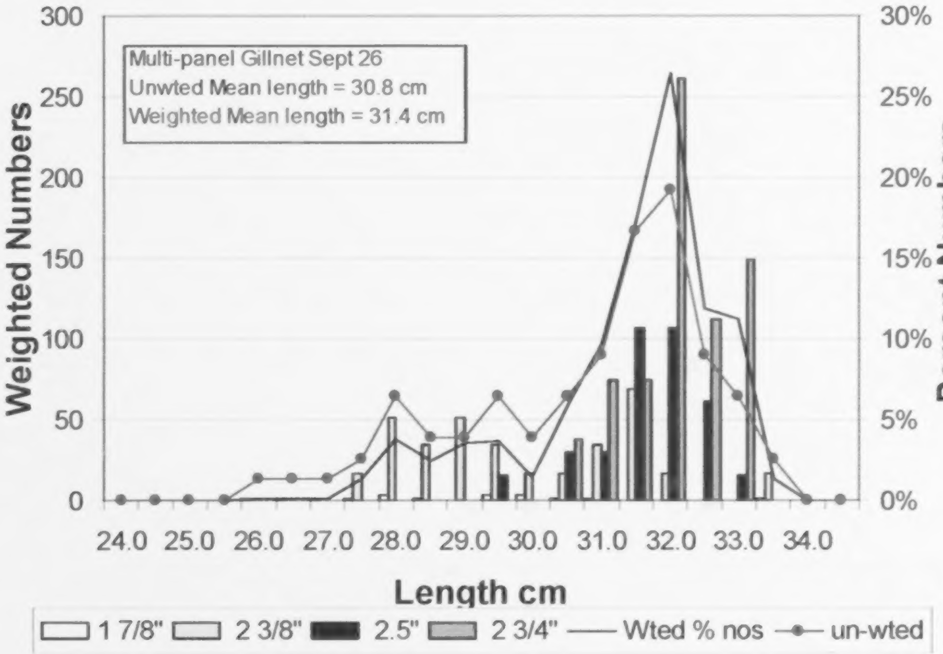


Figure 78. Multi-panel herring gillnet sample collected on September 26, 2010, for Halifax/Eastern Shore survey #1 on September 26, 2010.

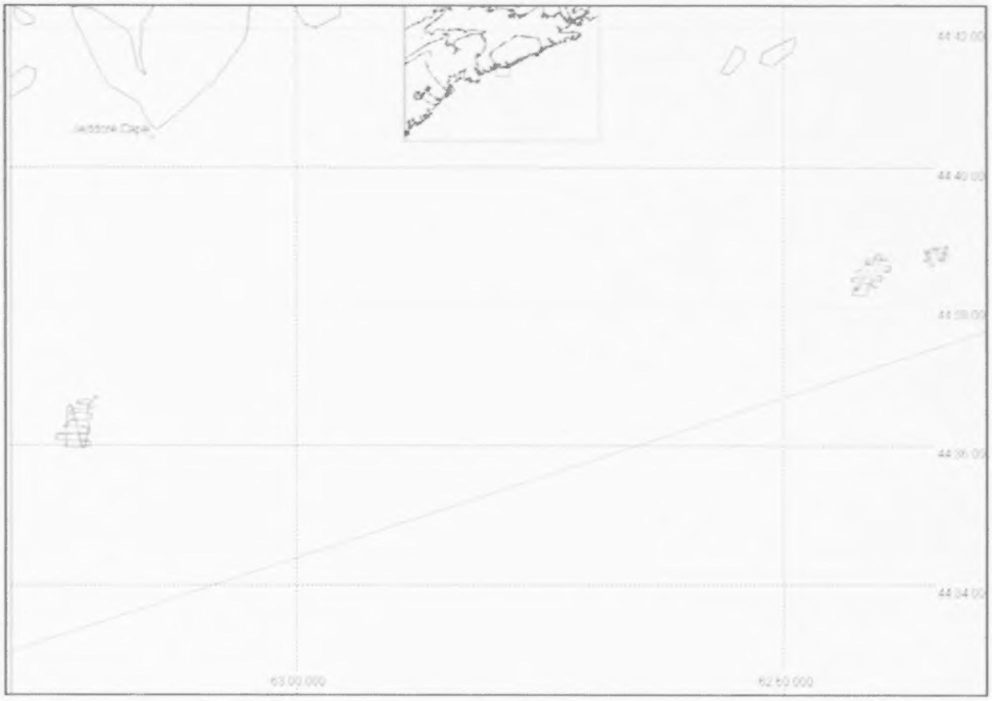

Jeddore Cape
44 42 00
44 40 00
44 38 00
44 36 00
44 34 00
63 00 000
62 50 000

Figure 79. Halifax/Eastern Shore herring gillnet survey lines for October 4-5, 2010, school surveys conducted by two acoustic survey vessels, the Bradley K and the Miss Owls Head.

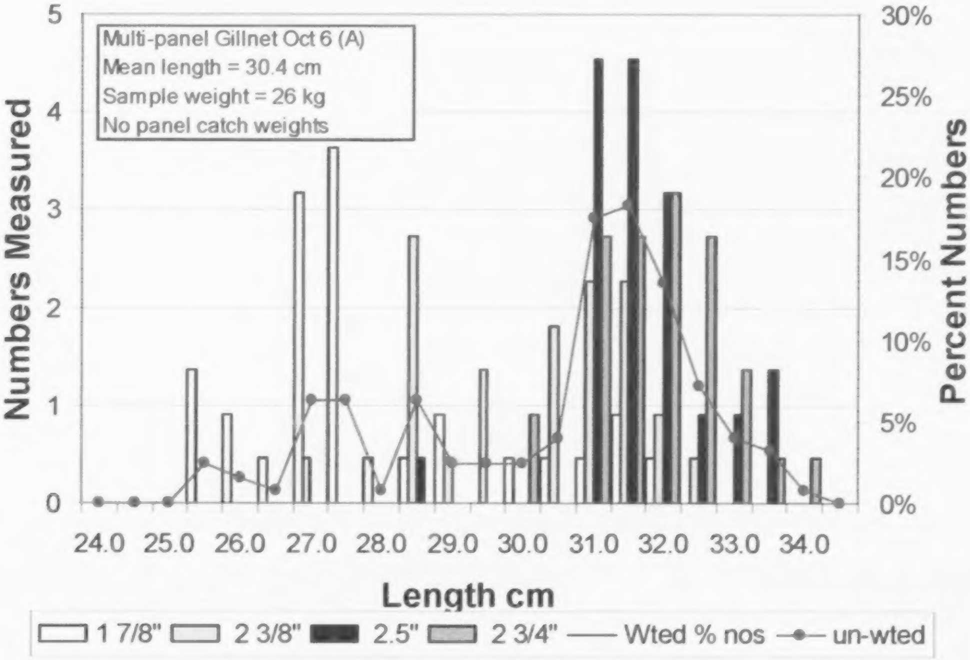


Figure 80. Multi-panel herring gillnet sample collected by Bradley K. (missing panel catch weights) October 5, 2010, for Halifax/Eastern Shore survey #2 on October 5.

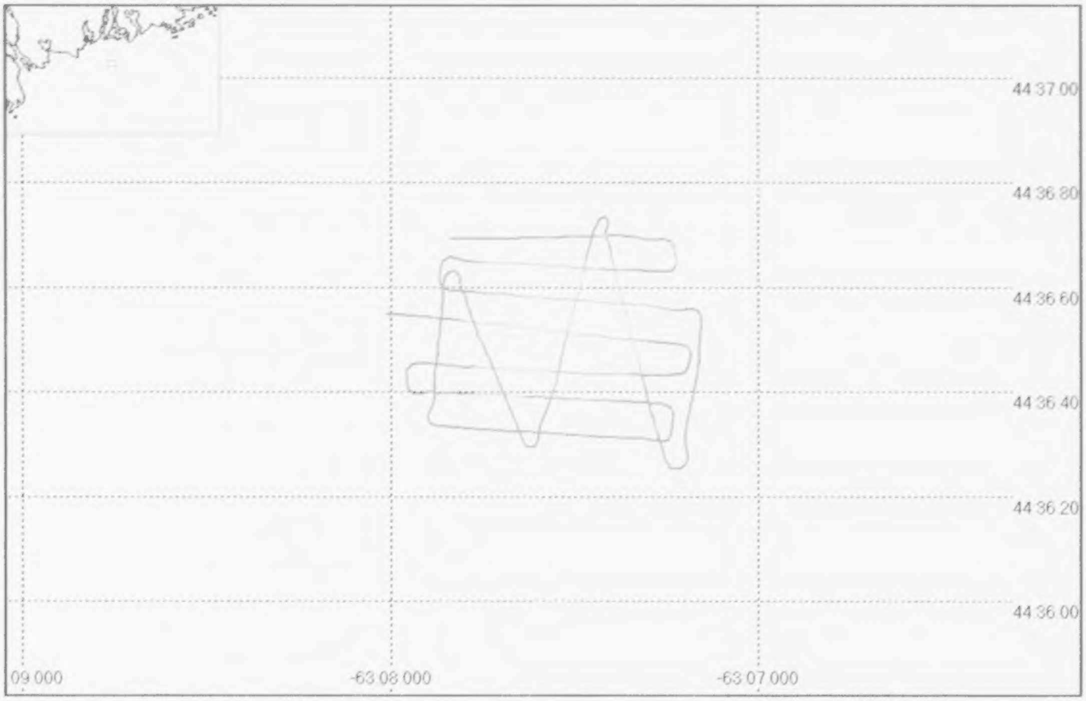

44 37.00
44 36.80
44 36.60
44 36.40
44 36.20
44 36.00
09.000
-63 08.000
-63 07.000

Figure 81. Halifax/Eastern Shore acoustic transects for October 12 survey conducted by one acoustic survey vessel, the Miss Owls Head.

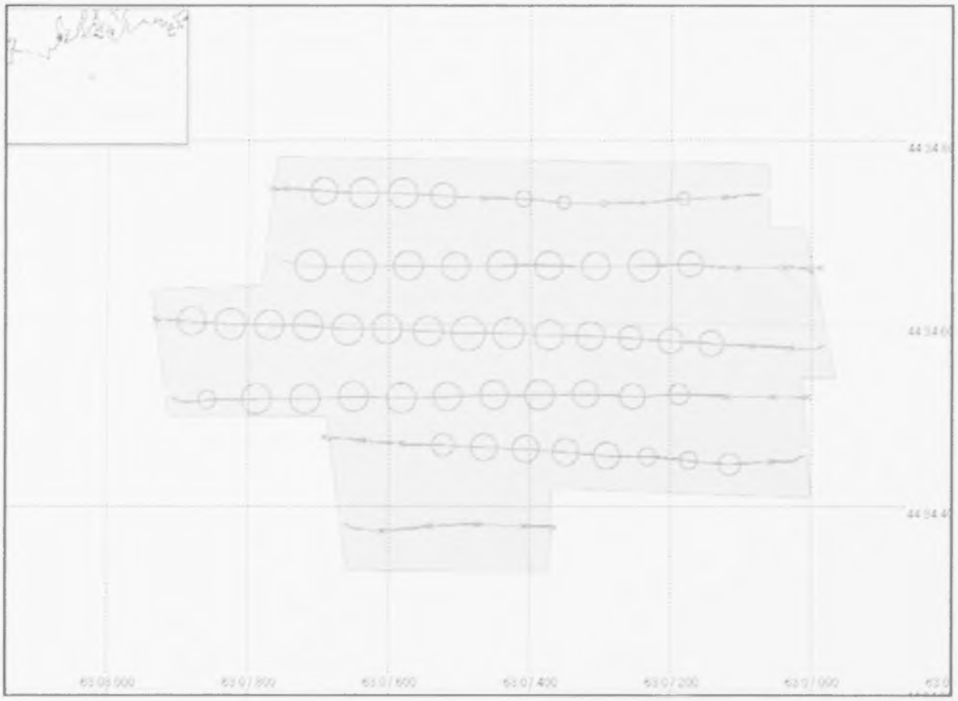

44 34.8
44 34.6
44 34.4
63 08.000
63 07.800
63 07.600
63 07.400
63 07.200
63 07.000
63.0

Figure 82. Halifax/Eastern Shore acoustic transects for October 20, 2010, survey conducted by one acoustic survey vessel, the Bradley K.

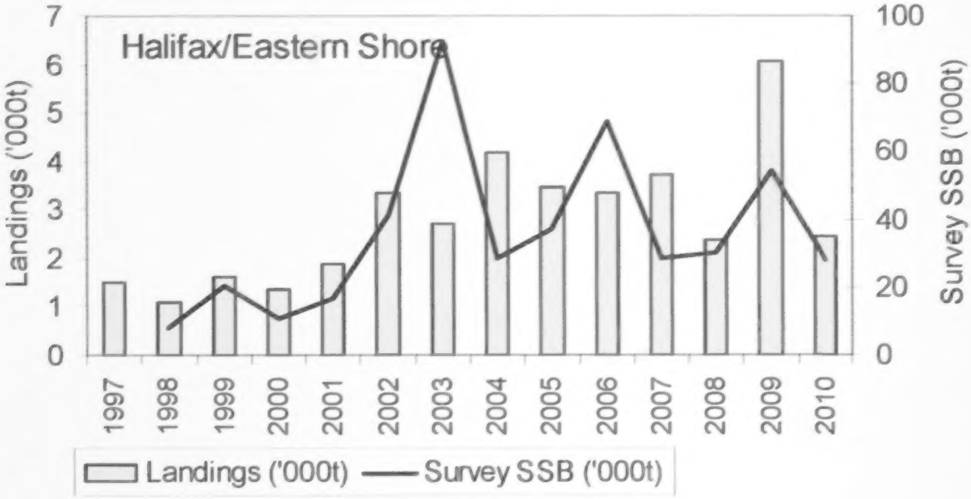


Figure 83. Halifax/Eastern Shore herring catches and acoustic survey biomass estimates from 1997-2010. (Acoustic survey SSB 1998-2002 'without' the CIF; 2003-2010 with the CIF).

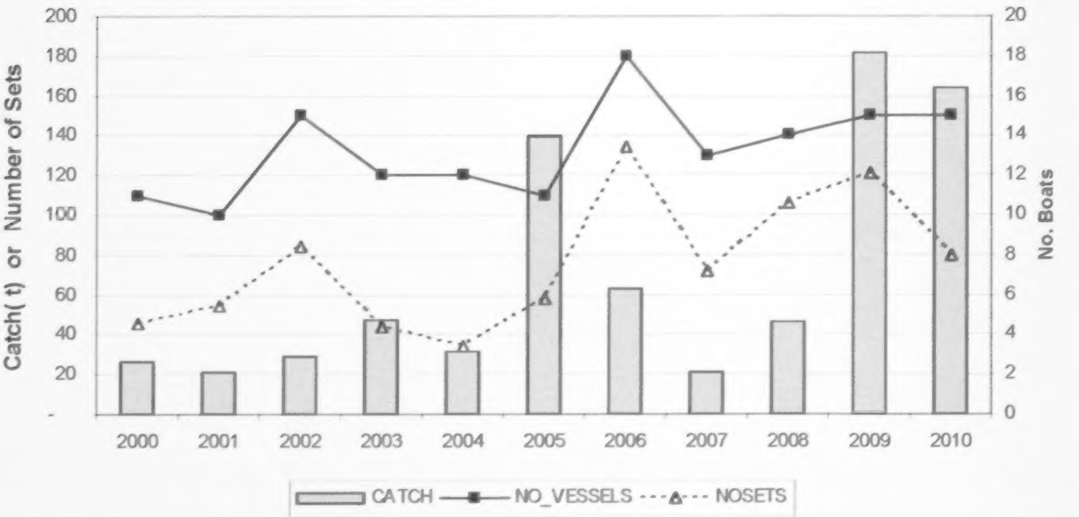


Figure 84. 2000-2010 herring gillnet total catch (t) and total effort in number of vessels and number of sets for the Lunenburg Box area from Liverpool to Chebucto Head area (statistical districts 22-26).

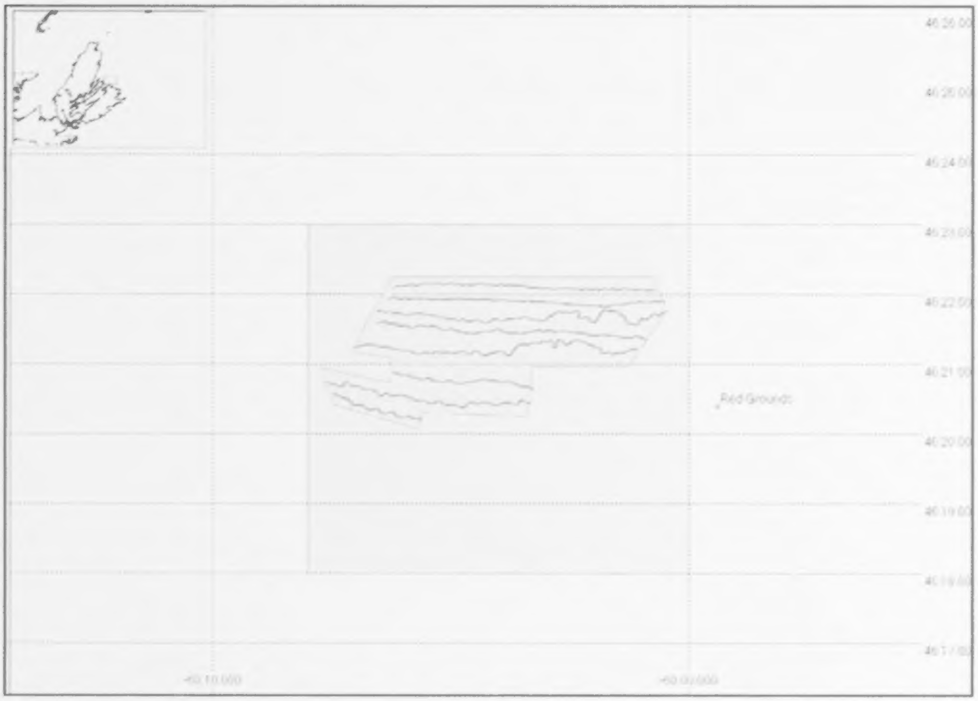

46 26.00
46 25.00
46 24.00
46 23.00
46 22.00
46 21.00
Red Grounds
46 20.00
46 19.00
46 18.00
46 17.00
-60 10.000
-60 00.000

Figure 85. Glace Bay herring gillnet survey lines on October 20, 2010.

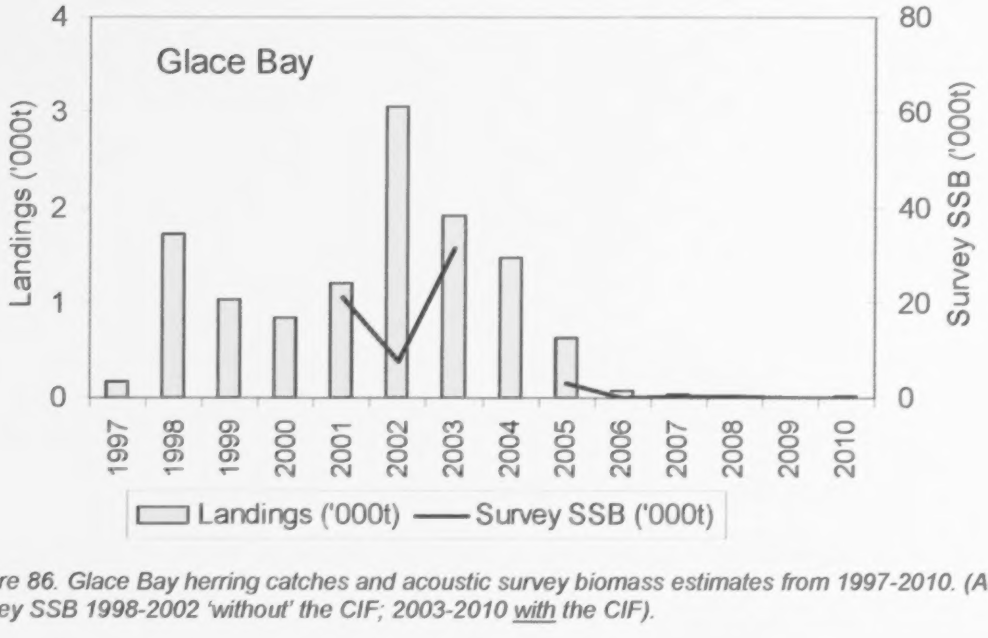


Figure 86. Glace Bay herring catches and acoustic survey biomass estimates from 1997-2010. (Acoustic survey SSB 1998-2002 'without' the CIF; 2003-2010 with the CIF).

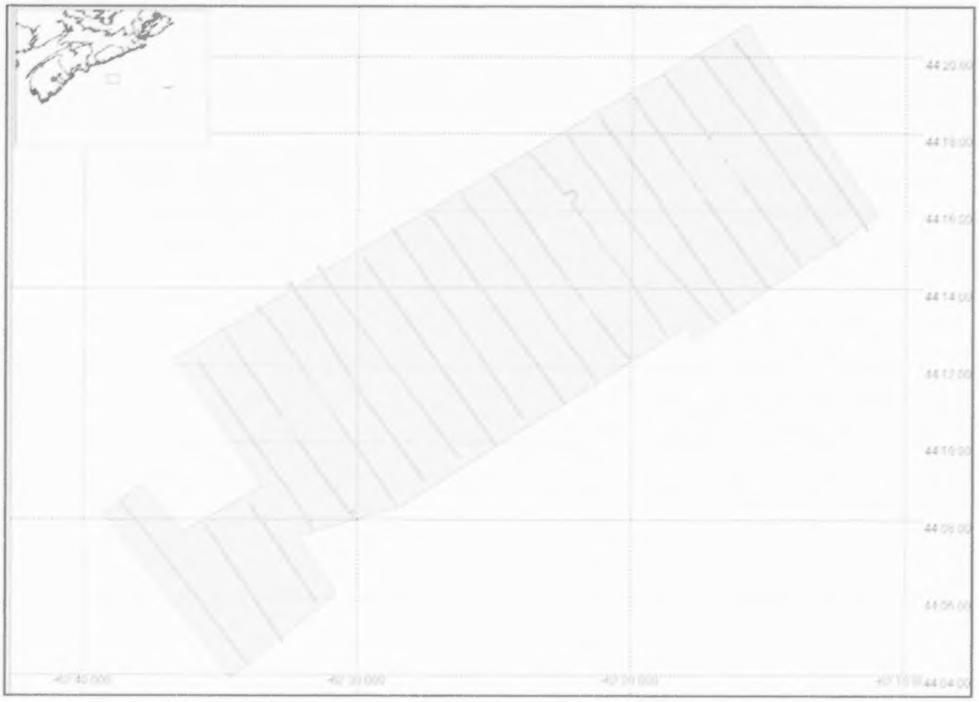

44 20.00
44 18.00
44 16.00
44 14.00
44 12.00
44 10.00
44 08.00
44 06.00
44 04.00
-60 40.000
-60 30.000
-60 20.000

Figure 87. Herring acoustic survey transects near 'The Patch' on the Offshore Banks on June 8, 2010, with 10 purse seine vessels participating.

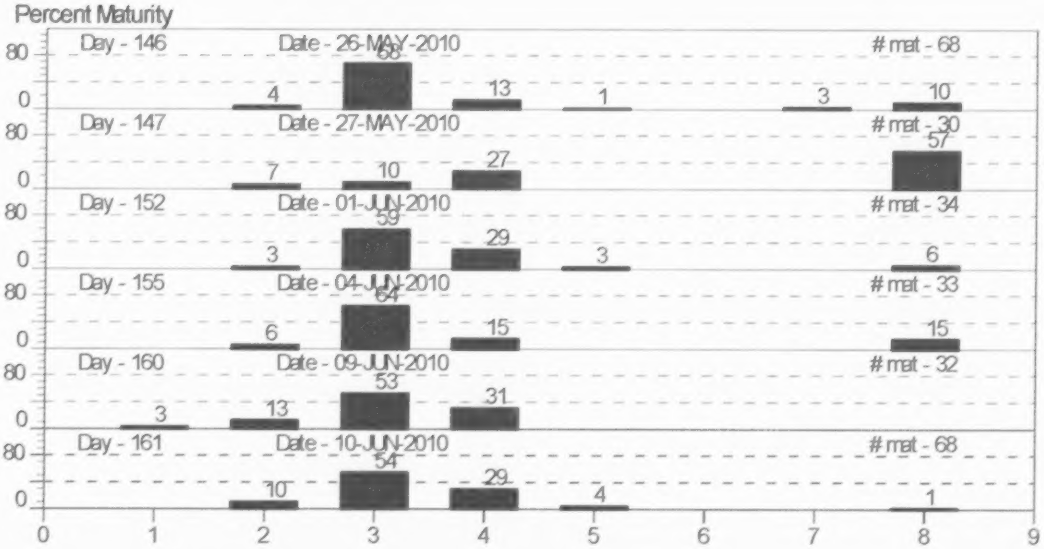


Figure 88. 2010 Offshore Banks purse seine maturity samples.

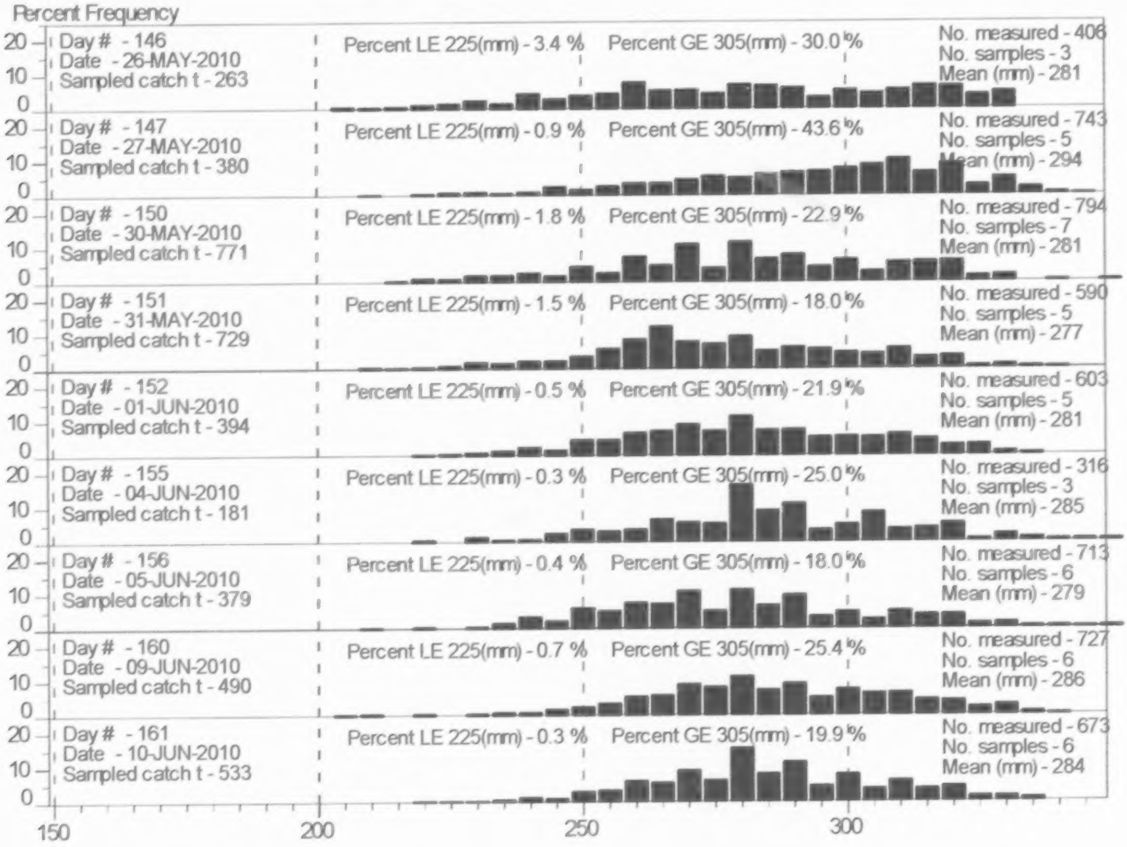


Figure 89. 2010 Offshore Banks purse seine length samples.

APPENDIX A. ACOUSTIC SURVEYS SUMMARY DETAILS BY SURVEY

Table A1. Scots Bay acoustic survey (#1) on June 26, 2010, for the inbox area alone (with CIF) using standard values for sample TS.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Bp_and_c100_only	-35.78	430	-51.647	0.026	11,136	7,741	70

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Bp_and_c100_only	C210801H	40.74	-35.78	-62.71	0.002
	B410800H	42.20	-35.78	-51.65	0.026
	B410801H	42.14	-35.78	-46.89	0.077
	C210800H	46.35	-35.78	-77.53	0.000

Table A2. Scots Bay acoustic survey (#2) on July 10, 2010, for the inbox and outbox areas separately (with CIF) using sample TS from fishery samples on July 9 to 11.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Survey_box	-35.35	530	-50.841	0.028	14,982	9,383	63
Outside_box	-35.29	170	-54.185	0.013	2,190	243	11
Total	-35.32	700	-51.448	0.025	17,172	9,386	55%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Survey_box	P410800H_inbox	16.78	-35.43	-44.18	0.133
	A410800H	42.17	-35.27	-47.42	0.061
	A410801H	40.81	-35.27	-52.32	0.020
	B410800H	45.60	-35.43	-54.58	0.012
	B410801H	43.07	-35.43	-51.55	0.024
	C210800H	38.66	-35.43	-59.66	0.004
	C210801H	38.00	-35.43	-60.01	0.003
Outside_box	P410801H	29.89	-35.43	-53.71	0.015
	M410800H	30.96	-35.16	-55.18	0.010
	M410801H	22.17	-35.16	-53.21	0.016
	P410800H_outbox	14.42	-35.43	-55.09	0.011

Table A3. Scots Bay acoustic biomass estimates from a fishing night survey near Advocate Bay on July 10, 2010, on three separate school areas (with CIF) using sample TS from fishery samples on July 9 to 11.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Advocate_school1	-35.43	0.28	-32.90	1.791	502	267	53
Advocate_school2	-35.93	0.20	-26.10	9.618	1,924	795	41
Advocate_school3	-36.16	0.06	-20.50	36.843	2,211	1,304	59
Total	-35.84	0.54	-26.64	8.584	4,636	1,550	33%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Advocate_school1	C210900H	0.64	-35.43	-1018.05	0.000
	C210901H	0.88	-35.43	-29.37	4.033
	C210902H	0.44	-35.43	-67.07	0.001
	C210903H	0.53	-35.43	-33.06	1.726
Advocate_school2	B410900H	0.94	-35.43	-26.71	7.445
	M410900H	0.90	-36.16	-28.66	5.619
	M410901H	0.64	-36.16	-23.52	18.358
Advocate_school3	M410902H	0.28	-36.16	-18.51	58.176
	M410903H	0.27	-36.16	-24.49	14.700

Table A4. Scots Bay acoustic survey (#3) on July 24, 2010, for the inbox and outbox areas separately (with CIF) using sample TS from fishery samples on July 25 and 26.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Scots_inbox_07_24	-35.13	580	-53.935	0.013	7,639	2,519	33
Scots_outbox_07_24	-35.20	220	-56.072	0.008	1,800	430	24
Total	-35.17	800	-54.426	0.012	9,439	2,555	27%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Scots_inbox_07_24	B410800H	48.56	-35.35	-58.15	0.005
	B410801H	47.46	-35.35	-61.00	0.003
	C210800H	41.88	-35.35	-62.34	0.002
	C210801H	40.65	-35.35	-66.97	0.001
	L410800H	36.98	-35.08	-52.83	0.017
	L410801H	36.16	-35.08	-48.16	0.049
	M410800H	38.44	-35.08	-56.64	0.007
	M420800H	39.75	-35.08	-51.09	0.025
	M420801H	39.79	-35.08	-56.08	0.008
	N410800H	44.69	-35.19	-51.50	0.023
	N410801H	43.55	-35.19	-54.53	0.012
Scots_outbox_07_24	A410800H	24.14	-35.19	-57.26	0.006
	A410801H	23.12	-35.19	-59.58	0.004
	K410800H	32.70	-35.35	-55.95	0.009
	K410801H	31.36	-35.35	-58.36	0.005
	M410801H	35.89	-35.08	-53.40	0.015

Table A5. Scots Bay acoustic survey (#4) on August 7, 2010, for the inbox and outbox areas separately (with CIF) using sample TS from fishery samples on August 8 and 9.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Scots_inbox_aug_07	-35.06	625	-52.068	0.020	12,461	3,143	25
Scots_outbox_aug_07	-35.11	200	-57.840	0.005	1,067	142	13
Total	-35.09	825	-52.921	0.016	13,528	3,146	23%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Scots_inbox_aug_07	A410800H	36.97	-35.04	-57.40	0.006
	A410801H	37.16	-35.04	-62.01	0.002
	B410800H	47.02	-35.20	-62.14	0.002
	B410801H	45.86	-35.20	-55.62	0.009
	C210800H	48.46	-35.20	-49.75	0.035
	C210801H	48.35	-35.20	-46.62	0.072
	L410800H	48.66	-34.94	-50.33	0.029
	L410801H_dup2	47.82	-34.94	-51.29	0.023
	M410800H_dup1	37.53	-34.94	-50.98	0.025
	M410801H	37.49	-34.94	-53.34	0.014
	M420800H	48.27	-34.94	-54.09	0.012
	M420801H	48.28	-34.94	-50.77	0.026
	P410800H	35.34	-35.20	-59.63	0.004
	S510800H	45.78	-35.04	-57.33	0.006
Scots_outbox_aug_07	I410800H_NAV_NOISE	29.64	-35.04	-56.49	0.007
	I410801H_NAV_NOISE	21.38	-35.04	-59.95	0.003
	K410800H	33.48	-35.20	-57.69	0.006
	K410801H	33.85	-35.20	-56.93	0.007
	N410800H	32.30	-35.04	-56.48	0.007
	N410801H	30.77	-35.04	-58.74	0.004
	P410801H	35.36	-35.20	-60.88	0.003

Table A6. Scots Bay acoustic survey (#5) on August 21, 2010, for the inbox and outbox areas separately (with CIF) using TS from fishery samples on August 22 and 23.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Scots_inbox_aug21	-34.81	540	-54.032	0.012	6,454	3,851	60
Scots_outbox_aug21	-34.70	100	-52.777	0.016	1,557	1,449	93
Total	-34.76	640	-53.810	0.013	8,011	4,115	51%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Scots_inbox_aug21	A410800H	41.46	-34.79	-46.94	0.061
	A410801H	35.69	-34.79	-56.14	0.007
	B410800H	45.20	-34.95	-60.42	0.003
	B410801H	38.47	-34.95	-59.74	0.003
	C210800H	43.43	-34.95	-58.26	0.005
	C210801H	34.73	-34.95	-61.97	0.002
	M410800H	38.41	-34.69	-54.27	0.011
	R410800H_sonar_noise	39.72	-34.95	-63.94	0.001
Scots_outbox_aug21	M410801H	31.05	-34.69	-49.85	0.030
	R410801H_sonar_noise	32.97	-34.95	-63.14	0.002

Table A7. Scots Bay acoustic survey (#6) on September 5, 2010, for the inbox and outbox areas separately (with CIF) using TS from fishery samples on September 6.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Scots_inbox_sep05	-34.89	560	-63.601	0.001	754	471	62
Scots_outbox_sep05	-34.89	100	-58.037	0.005	484	270	56
Total	-34.89	660	-62.158	0.013	1,238	543	44%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Scots_inbox_sep05	A410800H	40.01	-34.97	-61.86	0.002
	B410800H	45.56	-35.13	-74.42	0.000
	B410801H	34.85	-35.13	-1035.42	0.000
	C210800H	43.08	-35.13	-77.35	0.000
	C210801H	34.77	-35.13	-78.66	0.000
	M410800H	38.38	-34.86	-56.49	0.007
	M420800H	40.18	-34.86	-63.11	0.001
	M420801H	32.72	-34.86	-80.23	0.000
Scots_outbox_sep05	A410801H	33.25	-34.97	-61.49	0.002
	M410801H	31.28	-34.86	-56.04	0.008

Table A8. German Bank acoustic survey (#1) on August 18, 2010, with biomass estimates separately for 'Inbox' and 'Outbox' areas (as calculated with CIF).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_inbox_08_18	-35.14	646	-44.191	0.124	80,370	17,333	22
German_outbox_08_18	-35.11	25	-42.270	0.192	4,810	1,644	34
Total of entire survey	-35.13	671	-44.102	0.127	85,180	17,411	20%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
German_inbox_08_18	I410802H	36.00	-35.15	-43.19	0.157
	I410801H	37.00	-35.15	-49.41	0.038
	D410800H	37.03	-35.15	-53.53	0.015
	D410801H	37.36	-35.15	-48.19	0.050
	K410802H	36.77	-35.31	-49.45	0.039
	K410804H	37.26	-35.31	-43.09	0.167
	L410802H	36.79	-35.04	-38.67	0.434
	L410804H	36.46	-35.04	-41.54	0.224
	M420800H	37.11	-35.04	-49.33	0.037
	M420802H	36.64	-35.04	-44.78	0.106
	N410802H	36.88	-35.15	-45.92	0.084
	N410801H	37.25	-35.15	-44.58	0.114
	P410802H	36.98	-35.31	-51.93	0.022
	P410804H	37.26	-35.31	-43.71	0.145
	S510802H	37.48	-35.15	-43.88	0.134
	S510804H	37.23	-35.15	-41.58	0.228
German_outbox_08_18	K410803H	2.43	-35.31	-49.13	0.042
	K410805H	3.00	-35.31	-41.57	0.237
	L410803H	5.12	-35.04	-37.37	0.586
	L410805H	6.24	-35.04	-48.01	0.051
	N410803H	1.78	-35.15	-46.33	0.076
	P410803H	1.70	-35.31	-45.43	0.097
	S510803H	3.96	-35.15	-43.54	0.145
	S510805H	2.04	-35.15	-50.96	0.026

Table A9. German Bank (#2), August 31, 2010, acoustic herring spawning survey analysis with 'Inbox' and 'Outbox' survey area estimates (as calculated ***with*** *the CIF).*

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_08_31_inbox	-34.95	646	-45.477	0.088	57,159	17,360	30
German_08_31_outbox	-34.84	80	-52.378	0.018	1,411	80	6
Total	-34.90	726	-45.875	0.081	58,570	17,360	30%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/mý)	Biomass Density (kg/mý)	
German_08_31_inbox	D410800H	37.17	-34.90	-58.73	0.004	
	D410801H	36.76	-34.90	-53.47	0.014	
	D410800H_COPY1	37.17	-34.90	-58.73	0.004	Sealife substitute
	D410800H_COPY2	37.17	-34.90	-58.73	0.004	Sealife substitute
	K410800H	37.07	-35.06	-43.83	0.133	
	K410801H	37.24	-35.06	-48.83	0.042	Line 2 with Needler
	M420800H	37.05	-34.79	-45.69	0.081	
	N410800H	37.17	-34.90	-45.70	0.083	
	N410801H	37.14	-34.90	-51.02	0.024	
	P410800H	36.36	-35.06	-42.36	0.186	Line 1 with Needler
	P410801H	36.48	-35.06	-47.25	0.060	
	S510800H	37.07	-34.90	-46.14	0.075	
	S510801H	36.97	-34.90	-42.93	0.157	
	T410800H	36.94	-34.90	-39.18	0.373	
German_08_31_outbox	M420801H	37.49	-34.79	-52.09	0.019	
	T410801H	36.35	-34.90	-52.69	0.017	

Table A10. German Bank acoustic survey (#3) on September 8, 2010, with analysis separately for 'Inbox' and 'Outbox' areas (as calculated ***with*** *the CIF). Data was excluded for the Morning Star due to sonar interference and for the Dual Venture due to a sounder saturation problem.*

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_2010_09_08_in	-34.94	646	-44.925	0.100	64,880	23,248	36
German_2010_09_08_out	-34.93	160	-54.055	0.012	1,959	1,012	52
Total	-34.94	806	-45.757	0.083	66,839	23,270	35%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)	
German_2010_09_08_in	I410801H	17.57	-34.95	-56.94	0.006	Noise problem; short line
	K410800H	37.15	-35.11	-66.00	0.001	
	K410801H	37.03	-35.11	-53.02	0.016	
	L410800H	35.53	-34.85	-40.80	0.254	
	N410800H	37.13	-34.95	-41.20	0.238	
	P410800H	37.09	-35.11	-47.68	0.055	
	P410801H	36.44	-35.11	-49.21	0.039	
	S510800H	37.10	-34.95	-58.98	0.004	
	S510801H	37.15	-34.95	-46.30	0.073	
	T410800H	36.38	-34.95	-39.70	0.335	Navigation problems
	T410801H	36.28	-34.95	-48.71	0.042	Navigation problems
German_2010_09_08_out	I410800H	32.22	-34.95	-58.10	0.005	Noise problem; short line
	L410801H	36.31	-34.85	-56.87	0.006	
	N410801H	37.18	-34.95	-51.06	0.024	

Table A11. German Bank acoustic survey (#4) on September 15, 2010, with revised analysis separately for 'Inbox' and 'Outbox' areas (as calculated with the CIF). The Island Pride data was excluded due to a significant noise problem.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_2010_09_15	-34.88	646	-44.995	0.097	62,867	25,355	40
German_2010_09_15_outbox	-34.81	120	-51.871	0.020	2,363	2,177	92
Total	-34.85	766	-45.572	0.085	65,230	25,448	39%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
German_2010_09_15	K410800H	37.11	-34.97	-51.15	0.024
	K410801H	37.05	-34.97	-65.68	0.001
	L410801H_SPEEDNOISE	36.84	-34.71	-57.54	0.005
	M420800H	37.15	-34.71	-64.99	0.001
	M420801H	37.00	-34.71	-47.74	0.050
	N410800H	37.01	-34.81	-48.18	0.046
	N410801H	37.09	-34.81	-38.43	0.435
	P410800H	37.13	-34.97	-47.66	0.054
	R410800H	37.07	-34.97	-39.29	0.370
	R410801H	37.00	-34.97	-45.18	0.095
	S510800H	36.91	-34.81	-63.36	0.001
	S510801H	36.68	-34.81	-47.96	0.048
	T410801H_SONAR	36.88	-34.81	-43.57	0.133
German_2010_09_15_outbox	L410800H_SPEEDNOISE	36.50	-34.71	-61.46	0.002
	P410801H	37.09	-34.97	-63.46	0.001
	T410800H_SONAR	36.16	-34.81	-47.32	0.056

Table A12. German Bank acoustic survey (#5) on September 23, 2010 (as calculated with the CIF). The survey box area was only partially covered for an area total of 425km^2.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_2010_09_23	-34.77	425	-48.847	0.039	16,637	7,991	48

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
German_2010_09_23	D410999H_SONAR	36.95	-34.84	-67.42	0.001
	K410999H	36.95	-35.00	-58.93	0.004
	L410999H_SPEED	36.70	-34.73	-46.73	0.063
	M420999H_SPEED	37.15	-34.73	-43.22	0.142
	N410999H	36.97	-34.84	-52.66	0.017
	P410999H	37.62	-35.00	-52.50	0.018
	S510999H_SPEED	38.01	-34.84	-49.99	0.031

Table A13. German Bank acoustic survey (#6) on October 5, 2010 (as calculated with the CIF), with analysis separately for the 'Inbox' and 'Outbox' areas covered. This analysis includes re-edits on the N410999 (Lady Noreen) line to remove some 'balls' near bottom.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_2010_10_05_in	-34.96	646	-48.852	0.041	26,346	14,668	56
German_2010_10_05_out_v2	-34.86	230	-48.600	0.042	9,722	9,389	97
Total	-34.91	876	-48.784	0.041	36,068	17,416	48%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
German_2010_10_05_in	D410999H	36.79	-34.86	-59.63	0.003
	K410999H	37.20	-35.02	-52.83	0.017
	L410999H	37.43	-34.75	-53.74	0.013
	M420999H_SONAR	37.08	-34.75	-58.44	0.004
	P410999H	37.04	-35.02	-42.68	0.171
	S510999H	37.25	-34.86	-47.53	0.054
	T410999H	35.90	-34.86	-51.27	0.023
German_2010_10_05_out_v2	I410999H	37.07	-34.86	-64.40	0.001
	N410999H_MJP_GDM_EDIT	37.69	-34.86	-45.68	0.083

Table A14. German Bank acoustic survey (#6) results for school transects only using different combinations of the lines (as calculated with the CIF).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
School_2010_10_05_horizontal_lines	-35.02	4.5	-34.310	1.177	5,296	1,617	31
School_2010_10_05_vertical_lines	-35.02	3.7	-35.600	0.875	3,236	2,266	70
School_2010_10_05_all_lines	-35.02	4.75	-34.888	1.030	4,894	1,624	33

Table A15. German Bank acoustic survey (#7) on October 19, 2010, with the inbox and outbox areas estimated separately and the overall total (calculated with CIF using sample TS).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_2010_10_19_inbox	-34.83	646	-53.920	0.012	7,972	2,113	27
German_2010_10_19_outbox	-35.04	230	-59.908	0.003	749	214	29
Total	-34.94	876	-54.869	0.010	8,721	2,124	24%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
German_2010_10_19_inbox	L410999H	36.92	-34.75	-52.20	0.018
	N410999H	37.10	-34.86	-52.40	0.018
	P410999H	36.99	-35.20	-63.88	0.001
	S510999H_SONAR	37.16	-34.86	-55.67	0.008
	T410999H_SONAR	36.75	-34.86	-52.68	0.017
German_2010_10_19_outbox	K410999H	37.61	-35.20	-59.00	0.004
	M420999H	36.38	-34.75	-61.11	0.002

Table A16. German Bank acoustic survey (#8) on October 26, 2010, for the inbox area alone (with CIF) using sample TS from fishery samples on October 14.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
German_2010_10_26	-34.8	646	-57.080	0.006	3,820	1,435	38

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
German_2010_10_26	K410800H	35.61	-35.20	-61.84	0.002
	K410801H	37.01	-35.20	-64.56	0.001
	L410800H	37.16	-34.75	-52.34	0.017
	L410801H	36.76	-34.75	-51.85	0.019
	M420800H_WEAK	37.60	-34.75	-63.19	0.001
	M420801H_WEAK	35.90	-34.75	-55.45	0.009
	N410800H	37.13	-34.86	-60.02	0.003
	N410801H	37.06	-34.86	-58.29	0.005
	P410800H_SPEED	37.11	-35.20	-69.89	0.000
	P410801H_SPEED	37.08	-35.20	-64.74	0.001

Table A17. Stratum/school summary results for Little Hope/Port Mouton herring acoustic survey (#1) on September 21, 2010, as calculated with the CIF and standard TS values adjusted for frequency (no survey samples available).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
H700	-35.96	2.76	-47.03	0.078	215.8	47	22
H701	-35.96	0.35	-42.32	0.231	80.9	11	14
H702	-35.96	0.32	-35.35	1.153	369	117	32
H704	-35.96	0.68	-37.12	0.767	521.4	620	119
W700	-35.96	2.21	-32.35	2.299	5081.3	1476	29
W701	-35.96	0.47	-32.69	2.127	999.6	310	31
W702	-35.96	1.44	-34.38	1.439	2072.5	517	25
W703	-35.96	0.42	-35.47	1.121	470.7	265	56
W704	-35.96	0.31	-36.20	0.948	293.9	83	28
W705	-35.96	0.38	-35.33	1.156	439.4	138	31
W706	-35.96	1	-40.75	0.332	331.9	118	35
W707	-35.96	0.63	-34.57	1.380	869	312	36
Total (without repeat w700)	-35.96	10.97	-35.67	1.071	**11,746**	1,775	15

Table A18. Stratum/school summary results for Little Hope/Port Mouton herring acoustic survey (#2) on October 3, 2010, as calculated with the CIF and standard TS values adjusted for frequency (no survey samples available).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Sch01	-35.96	4.02	-53.28	0.019	74.6	18	24
Sch02	-35.96	2.43	-49.02	0.049	120.1	37	31
Sch03	-35.96	0.84	-41.60	0.273	229.4	96	42
Sch04_pass2	-35.96	0.81	-32.95	2.000	1,620	392	24
Total	-35.96	8.1	-41.94	0.252	**2,044**	406	20

Table A19. Stratum/school summary results for Little Hope/Port Mouton herring acoustic survey (#3) on October 11, 2010, as calculated with the CIF and TS values adjusted for frequency (using multi-panel gillnet sample).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Ww_sch01	-35.83	2.19	-31.94	2.449	5364.2	1038	19
Ww_sch02	-35.83	2.23	-38.18	0.582	1298.5	249	19
Ww_sch03	-35.83	5.75	-45.25	0.114	656.9	114	17
Skj_sch04	-35.83	1.02	-40.44	0.346	352.6	55	16
Skj_sch05	-35.83	1.72	-34.91	1.234	2122.7	335	16
Skj_sch06	-35.83	1.78	-32.51	2.145	3,819	2,559	67
Total	-35.83	14.69	-36.16	0.927	**13,614**	2,796	21

Table A20. Stratum/school summary results for Little Hope/Port Mouton herring acoustic survey (#4) on October 19, 2010, as calculated with the CIF and standard TS values adjusted for frequency (no survey samples available).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Ww_east	-35.96	1.19	-32.37	2.290	2725.5	1051	39
Ww_west	-35.96	0.69	-27.54	6.961	4802.9	496	10
Skj_sch01	-35.96	0.31	-47.69	0.067	20.8	8	38
Skj_sch02	-35.96	0.47	-40.14	0.382	179.6	58	33
Skj_sch03	-35.96	2.4	-39.43	0.451	1081.2	262	24
Skj_sch04_	-35.96	1.5	-40.78	0.330	495	161	33
Total	-35.96	6.56	-34.45	1.418	**9,305**	1,204	13

Table A21. Stratum/school summary results for Little Hope/Port Mouton herring acoustic survey (#4) on October 24, 2010, as calculated with the CIF and standard TS values adjusted for frequency (no survey samples available).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Skj_east	-35.96	0.5	-32.95	2.002	1001	260	26
Skj_west	-35.96	1.0	-40.83	0.326	326	221	68
Totals	-35.96	1.5	-36.50	0.885	**1,327**	341	26

Table A22. Transect summary for Halifax/Eastern Shore herring acoustic survey (#1) on September 26, 2010, as calculated with the CIF and TS values adjusted for frequency from multi-panel net sample.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Esfpa_2010_09_26	-36.24	2.5	-29.075	5.208	**13,021**	2,406	18

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Esfpa_2010_09_26	M510800H	1.66	-36.24	-27.89	6.844
	M510801H	1.42	-36.24	-26.53	9.357
	M510802H	1.61	-36.24	-30.07	4.142
	M510803H	1.57	-36.24	-27.79	6.995
	M510804H	1.43	-36.24	-30.00	4.211
	M510805H	1.29	-36.24	-29.01	5.292
	M510806H	1.41	-36.24	-32.02	2.643
	M510807H	1.32	-36.24	-38.20	0.638
	M510808H	1.53	-36.24	-27.46	7.547
	M510809H	0.44	-36.24	-1016.42	0.000

Table A23. Transect summary for Halifax/Eastern Shore herring acoustic survey (#2) on October 5, 2010, for main schools only as calculated with the CIF and TS values adjusted for frequency from multi-panel net samples.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Bk_2010_10_05_sch01	-35.76	0.75	-27.636	6.489	4,867	1,221	25
Moh_2010_10_05_sch01	-35.88	0.22	-27.019	7.696	1,693	540	32
Moh_2010_10_04_sch01	-35.88	0.94	-34.229	1.463	1,376	488	35
Total	-35.84	1.91	-29.620	4.155	**7,935**	1,421	18%

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Bk_2010_10_05_sch01	B510800H	0.58	-35.76	-1017.65	0.000
	B510801H	0.65	-35.76	-26.31	8.815
	B510802H	0.85	-35.76	-26.03	9.394
	B510803H	0.68	-35.76	-25.81	9.871
	B510804H	0.76	-35.76	-25.19	11.401
	B510805H	0.67	-35.76	-31.30	2.789
	B510806H	0.63	-35.76	-29.61	4.118
	B510807H	0.36	-35.76	-48.20	0.057
Moh_2010_10_05_sch01	M510800H	0.58	-35.88	-28.23	5.820
	M510801H	0.60	-35.88	-28.06	6.055
	M510802H	0.54	-35.88	-28.60	5.345
	M510803H	0.56	-35.88	-26.15	9.397
	M510804H	0.58	-35.88	-23.15	18.751
	M510805H	0.61	-35.88	-35.55	1.080
Moh_2010_10_04_sch01	M510900H	0.62	-35.88	-29.55	4.302
	M510901H	0.59	-35.88	-37.53	0.685
	M510902H	0.61	-35.88	-35.26	1.153
	M510903H	0.70	-35.88	-30.63	3.348
	M510904H	0.91	-35.88	-36.70	0.829
	M510905H	0.89	-35.88	-49.87	0.040
	M510906H	0.67	-35.88	-57.87	0.006
	M510907H	0.52	-35.88	-31.26	2.896
	M510908H	0.46	-35.88	-37.41	0.703

Table A24. Transect summary for Halifax/Eastern Shore herring acoustic survey (#3) on October 12, 2010, as calculated with the CIF and standard TS values adjusted for frequency (no samples available).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Esfpa_2010_10_12	-35.96	0.75	-38.097	0.612	**459**	159	35

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Esfpa_2010_10_12	M510800H	1.05	-35.96	-36.84	0.818
	M510801H	0.99	-35.96	-33.70	1.686
	M510802H	0.94	-35.96	-39.81	0.413
	M510803H	0.87	-35.96	-48.31	0.058
	M510804H	0.94	-35.96	-38.63	0.542
	M510805H	0.83	-35.96	-38.96	0.502
	M510806H	0.79	-35.96	-51.57	0.028

Table A25. Transect summary for Halifax/Eastern Shore herring acoustic survey (#4) on October 20, 2010, as calculated with the CIF and standard TS values adjusted for frequency (no samples available).

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Esfpa_2010_10_20	-35.96	0.77	-26.570	8.698	**6,697**	2,041	30

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
Esfpa_2010_10_20	B510800H	0.93	-35.96	-30.29	3.692
	B510801H	1.04	-35.96	-24.65	13.540
	B510802H	1.26	-35.96	-23.92	16.000
	B510803H	1.20	-35.96	-26.59	8.659
	B510804H	0.91	-35.96	-32.95	2.003
	B510805H	0.40	-35.96	-1016.03	0.000

Table A26. Transect summary results for Offshore Banks herring acoustic survey on 'The Patch' on June 8, 2010, as calculated with the CIF and standard TS values adjusted for frequency.

Stratum Layer 1	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
All_transects_except_sealife	-35.61	417	-56.273	0.009	**3,579**	1,441	40

Stratum Layer 1	Transect Number	Transect Length (km)	Target Strength (dB/kg)	Average Sa (/m2)	Biomass Density (kg/m2)
All_transects_except_sealife	D410800H	11.34	-35.62	-67.54	0.001
	D410801H	11.36	-35.62	-61.52	0.003
	I410800H	11.40	-35.62	-54.39	0.013
	I410801H	11.11	-35.62	-59.56	0.004
	K410800H	11.05	-35.78	-63.19	0.002
	K410801H	11.31	-35.78	-64.24	0.001
	L410800H	11.17	-35.51	-55.15	0.011
	L410801H	11.87	-35.51	-55.33	0.010
	M420800H	6.01	-35.51	-62.31	0.002
	M420801H	9.91	-35.51	-74.62	0.000
	N410800H	11.50	-35.62	-58.01	0.006
	N410801H	11.38	-35.62	-47.64	0.063
	P410800H	11.62	-35.78	-62.90	0.002
	P410801H	11.76	-35.78	-1030.70	0.000
	S510800H	11.45	-35.62	-52.34	0.021
	S510801H	11.74	-35.62	-58.47	0.005
	T410800H	11.66	-35.62	-60.33	0.003
	T410801H	11.63	-35.62	-60.90	0.003